SCIENCE TEACHER

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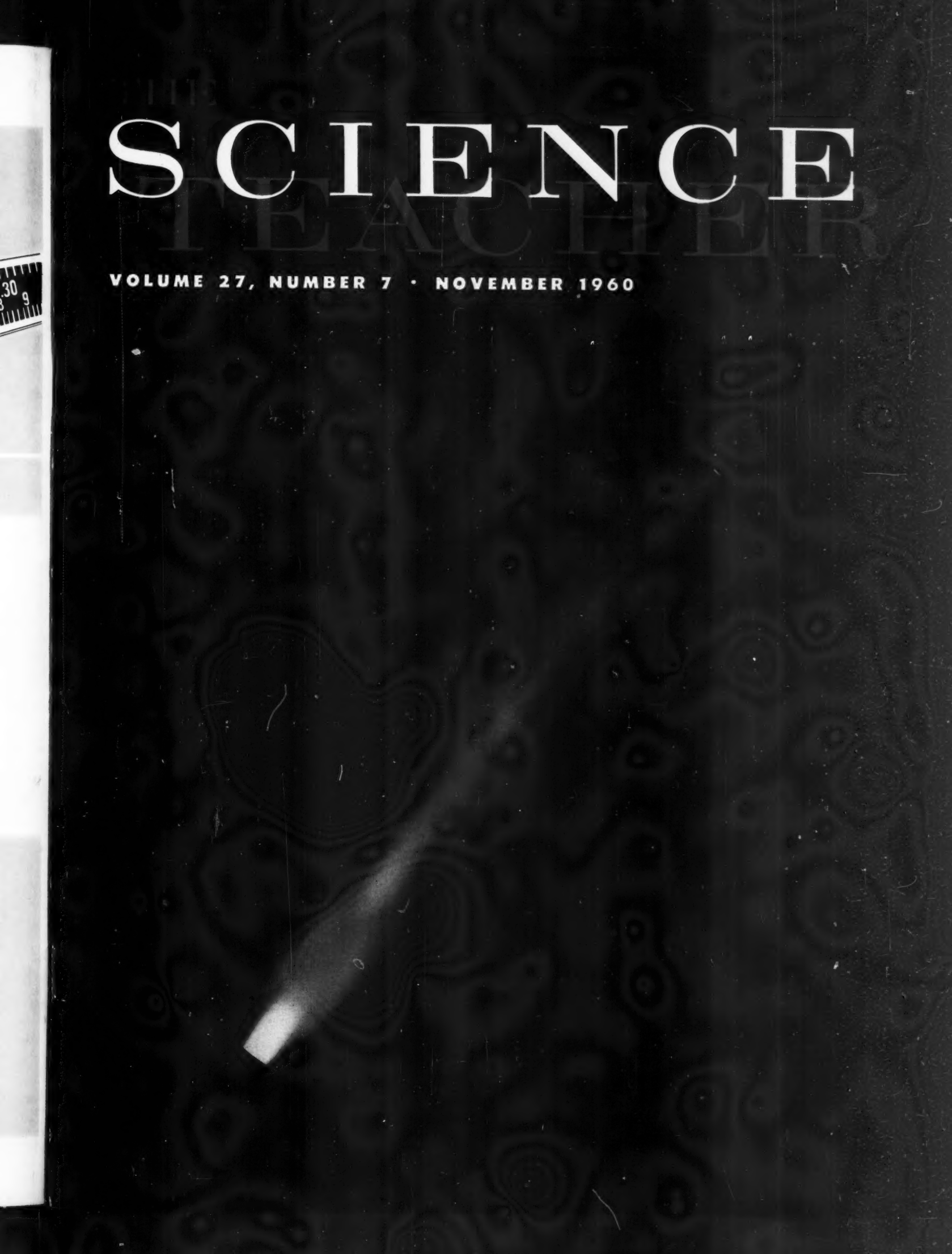

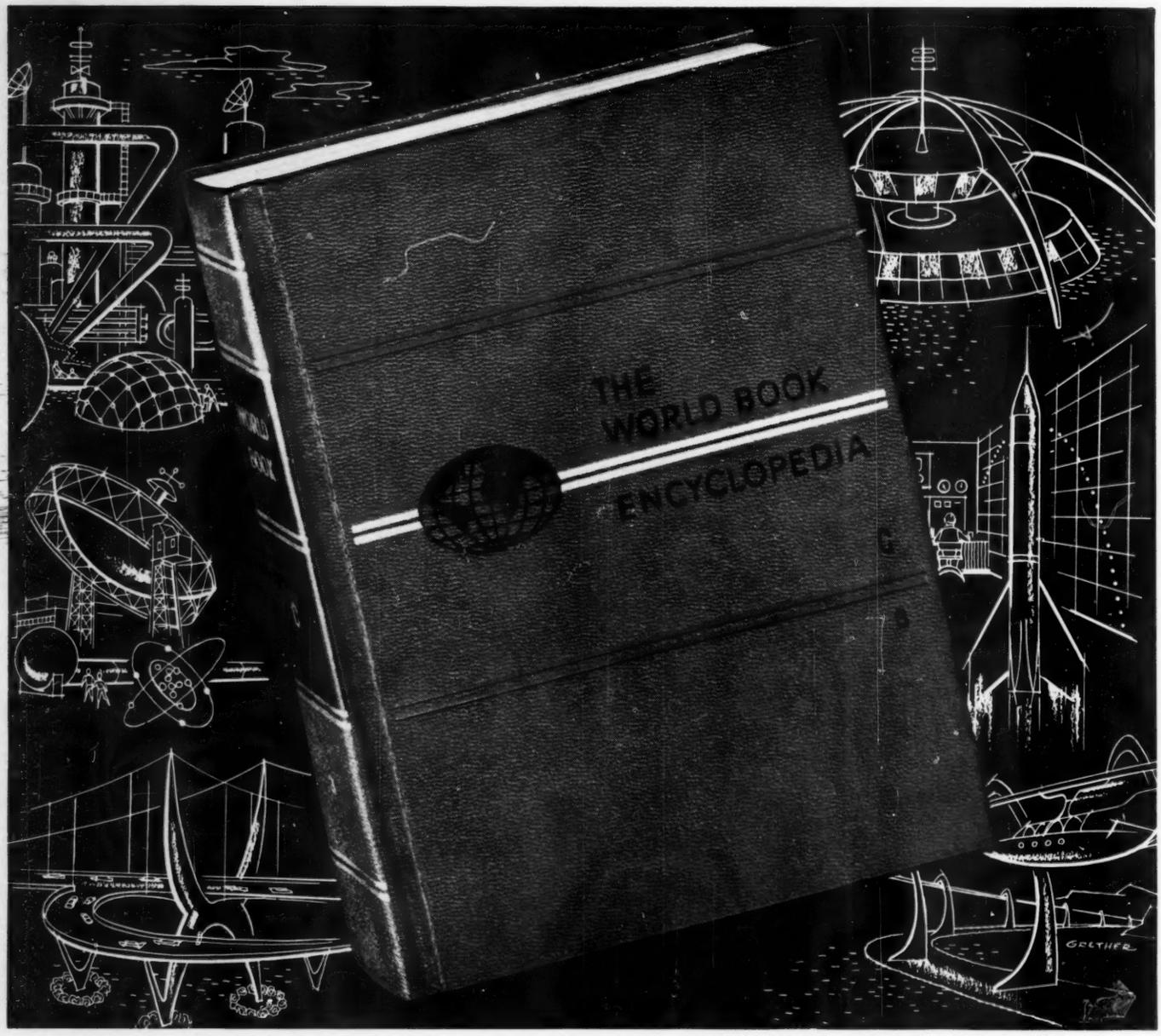

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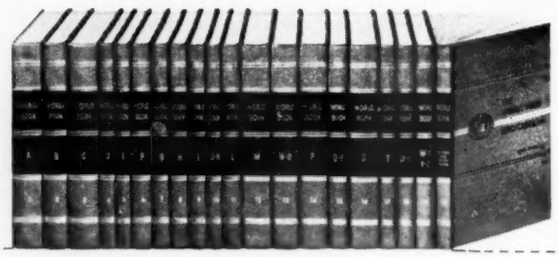

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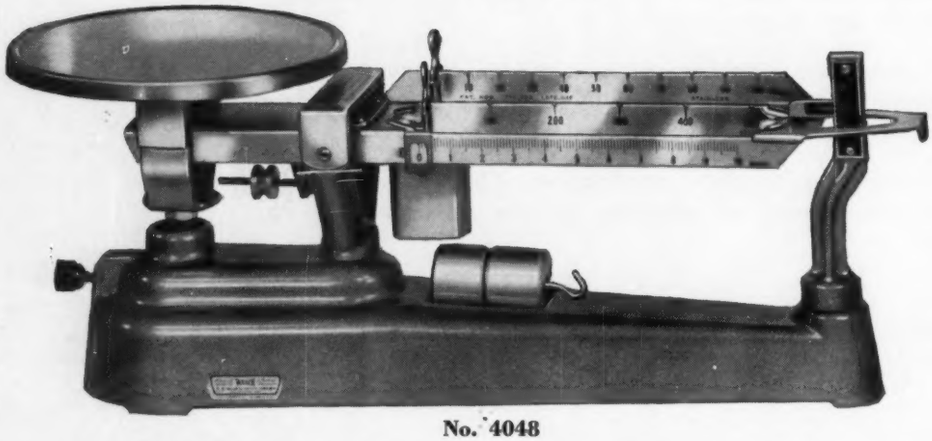

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THE SCIENCE TEACHER

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Volume 27, Number 7 • November 1960

THE PLASMA STATE
Tibor S. Laszlo 6

LOW LEVEL RADIOISOTOPE TECHNIQUES
John H. Woodburn 11

THE REGULATION OF PLANT GROWTH
Robert W. Stegner 18

NEW SCIENCE FILMS
Horizons of Science
Reported by *Wesley W. Walton* 23

Planet Earth
Reported by *Hugh Odishaw* 27

USES OF SURPLUS PROPERTY MATERIALS
Alan Mandell 32

REBUILDING THE SCIENCE PROGRAM
Inquiry Training in the Elementary School
J. Richard Suchman 42

The Quantitative Approach in Teaching Biology
Addison E. Lee 49

Opportunity in Junior High Science
Harry Cressman 55

THE ELEMENTARY SCHOOL SCIENCE REPORTER
Certification of Elementary School Teachers
Harold E. Tannenbaum 58

CLASSROOM IDEAS
Determining the Value of "g"
Phillip Crosby and Wendell F. Bennett 61

BOOK REVIEWS 65

SCIENCE TEACHING MATERIALS
Book Briefs 72
Professional Reading 75
Audio-Visual Aids 76
Apparatus and Equipment 80

EDITORIAL 4

LETTERS 5

NSTA ACTIVITIES 67

FSA ACTIVITIES 69

NSTA CALENDAR 59

INDEX OF ADVERTISERS 80

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The National Science Teachers Association is a department of the National Education Association and an affiliate of the American Association for the Advancement of Science. Established in 1895 as the NEA Department of Science Instruction and later expanded as the American Council of Science Teachers, it merged with the American Science Teachers Association and reorganized in 1944 to form the present Association.

The reorganization last year of our multitudinous projects and committee efforts into three large groupings, each under a Standing Committee to coordinate, stimulate, and report NSTA activities to members, was a major step forward in improved administration. This major step demonstrates that the Association has reached a level of professional maturity and development which is bringing us increased recognition and respect. This professional maturity is reflected in the high quality of professional services such as the annual convention, our magazine, and published reports of research, special studies, and conferences.

At the Los Angeles meeting of the Board this past June, two other actions were taken which will advance professional development for NSTA in the near future. One action was to establish a Finance Committee for the Association, and the other consisted of assigning to the Policies Committee broad responsibilities for guiding NSTA.

We can, perhaps, feel justifiably proud of the growth in our annual budget from somewhat less than $15,000 in 1944 to $560,000 in 1960. During this time, however, we have lived on a year-by-year basis with little opportunity to plan or budget ahead. We received financial aid from the NEA in the form of interest-free loans which totaled $23,000, and this helped the Association considerably in launching and establishing its program. During the past two years, our debt to NEA has been completely eliminated, thanks to some 3000 members of NSTA who contributed approximately $10,000 toward its retirement. And so it seemed to the Board that the stage was now set for NSTA to develop plans for solid, long-range financing. This is particularly important for an Association which derives less than 30 per cent of its total income from memberships and subscriptions. The new Finance Committee is being asked to design criteria and procedures for (1) the development of a reserve fund, (2) the acceptance of business-industry support of NSTA activities, and (3) the presentation of the Association program to all prospective contributors and supporters. The committee is comprised of NSTA's Finance Officer (formerly called the Treasurer) and four members appointed to four-year terms on a rotating basis. Serving for 1960-61 are J. Donald Henderson, University of North Dakota, Grand Forks; Past-President Philip G. Johnson, Cornell University, Ithaca, New York; Past-President Nathan A. Neal, McGraw-Hill Book Company, Inc., New York; Allison J. McNay, Standard Oil Company (California), San Francisco, California; and Virgil H. Heniser, Thomas Carr Howe High School, Indianapolis, Indiana.

The Association has had a Policies Committee for about ten years. The ten-point policy statement on which NSTA operates was developed by this committee and adopted by the Board of Directors in 1952. Another major accomplishment of this committee was a review of the minutes of all meetings of NSTA Boards of Directors and Executive Committees from 1944 through 1957 and the preparation of a collation of all actions which had the force of establishing policies for the Association. The committee has since kept this listing up to date through annual revisions. Now, however, this task is to be assigned to the Recording Secretary, and the Policies Committee is being asked to look ahead to where we should be going rather than backward to where we have been. A continuing scrutiny of NSTA goals and purposes, plus an evaluation of current projects and activities in relation to these, are part of the considerations which the committee will deliberate. It will be this committee's function to study and recommend to the Board new endeavors which will promote accomplishment of the basic purposes for which NSTA exists. More specifically, the committee has been asked to think about these questions: What should NSTA be doing ten years from now? What record of achievements and influence should the Association possess by 1965? How can NSTA function so that without it, there would be a serious gap in our area of the educational profession?

Members of this committee for 1960-61 are Milton O. Pella, University of Wisconsin, Madison, *Chairman;* Donald G. Decker, Colorado State College, Greeley; Archie L. Lacey, Hunter College, New York City; John H. Marean, Reno High School, Reno, Nevada; Herbert A. Smith, University of Kansas, Lawrence; and J. Hervey Shutts, Minneapolis Public Schools, Minneapolis, Minnesota.

I have chosen to tell you about these two committees this month because their work will be far less visible to members of NSTA than, say, the journal or a convention. But it seems to me that in setting ourselves to the task of taking a hard look ahead, both in terms of program and of finance, we are taking another big step forward in the professionalization of our Association. I am sure that members of these committees will want and will welcome inquiries, suggestions, and general comments from all interested members of NSTA.

Robert H. Carleton

New Membership Directory

The 1960 Membership Directory, listing the names and addresses of all NSTA individual members as of August 1, 1960, is now available. The regular price is $4. NSTA members, however, may purchase the directory for $1. Free distribution of the directory has been made to life and sustaining members, committee chairmen, officers and directors of the organization, and state membership chairmen. This is the first publication of a directory since 1957. The officers and staff of the NSTA welcome your comments and suggestions.

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Volume 27, No. 7 — November 1960

The Journal of the National Science Teachers Association, published by the Association monthly except January, June, July, and August. Editorial and executive offices, 1201 Sixteenth Street, N.W., Washington 6, D. C. Of the membership dues (see listing below) $3 is for the Journal subscription. Single copies, $1.

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Cosmogony-Evolution: A Thematic Approach

During a National Science Foundation Institute at the University of Oklahoma, I took a course developed by Dr. Carlton W. Berenda, physicist and chairman of the Philosophy Department. The course is an approach to general science on the theme of cosmogony-evolution.

Based on the experience with our students, it is my opinion that this unified approach to general science is superior to others now taught. My school is willing to mail the dozen-page course of study to any interested teacher who wishes to explore it. Just write me at the address below.

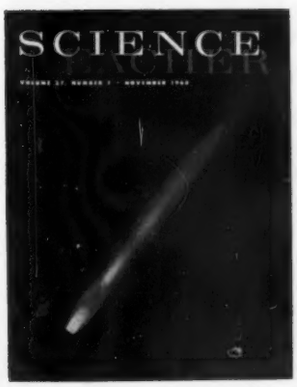
In the cosmogony-evolution method, one central problem guides the classroom activities throughout the year. In attempting to answer such questions as "How did it all begin?" and "What is the scientific history of the world?" the students are shown how the different areas of science cooperate to solve some perplexing and fascinating problem. During the year the students inquire first into the size, age, and structure of our universe by a study of astronomy and the related disciplines of optics, physics, and mathematics. Then, through a study of nuclear physics and chemistry, the students investigate the nature and origin of the elements from primitive energy-matter and from hydrogen and helium in the hot interiors of stars. Through a study of geology the students learn the nature, origin, and history of our planet. Through a study of biochemistry the students explore the origin of life in the early atmosphere. Finally, by way of biology and paleontology the students investigate the nature of living things and the evolution of the plant and animal kingdoms during the last billion years.

One handicap which we faced was the shortage of written material on these subjects appropriate for the secondary school level. Though considerable material has been written on the various topics, some of which is within the grasp of the students, it is scattered over such a wide range of books and periodicals that it is difficult to provide each student with immediately accessible literature. This year we have issued to each student six paper-bound books and some mimeographed material. There is a need for a single book which would not only trace the cosmogony-evolution theme, but would also serve as an introduction to more technical writings.

Our approach is to start each unit of study with an investigation of a portion of the world about us. We perform experiments and demonstrations, observe filmstrips and movies, read and think. Only at the end of each unit are we in a position to understand the hypotheses that are tentatively offered by scientists about the early history of our world. During the school year the pieces fall into place, and by the end of the term the students have a connected picture (or "theory" or "vision") of the scientific history of the world.

There are still some rough edges in the cosmogony-evolution theme to be smoothed out, but perhaps within the foreseeable future it will be possible to offer to science teachers more information about this new and fascinating method of teaching advanced courses in general science. I will be glad to exchange views with anyone who wishes to examine the course.

MITCHELL MODISETT
The Junior-Senior High School
Mahwah, New Jersey



THIS MONTH'S COVER . . .

A plasma arc fired with argon has been photographed as the plasma issues from a 30-kw prototype engine designed for space propulsion (Avco Research and Advanced Development Division, Wilmington, Massachusetts).

The science which is concerned with the dynamics of plasmas and conducting liquids in an electromagnetic field is called magnetohydrodynamics (MHD). Important results have been achieved in the application of principles of MHD.

The plasma state as interpreted in the lead article may be considered as the fourth state of matter.

NEA NOTES

EDITOR'S NOTE: From time to time, we will report events and data of interest from the other NEA units in this column. Additional information on the items reported may be obtained by writing the individual groups.

NEA Instructional Program

The NEA has recently embarked upon a two-year project seeking to define and state the views of the organized profession on the nature of a program of elementary and secondary education which will be adequate to meet the needs of the years ahead. Ole Sand, professor of education on leave from Wayne State University, Detroit, Michigan, is director of the project, and Richard I. Miller of the NEA staff is assistant director.

Specifically, the project hopes to develop guidelines of assistance to local schools in deciding on their future instructional program. Special studies on social forces and trends, the present status of public education, and the issues in curriculum development will be examined.

The NEA Project on the Instructional Program of the Public Schools is an outgrowth of discussions by members of the NEA Council on Instruction, an informal body of thirty NEA units concerned with instruction improvement at all levels.

Catalog of Publications

Over 1000 educational publications—books, pamphlets, periodicals, proceedings, research reports, audio-visual materials—now may be found in one listing. The NEA Catalog of Publications was published in the September issue of the *NEA Journal*. A limited number of copies are available from the Publications Division, NEA. The September 1960 Catalog contains materials from nearly fifty specialized committees, commissions, and departments of the NEA. It is indexed by unit and by special subject listings. Each publication is identified by a permanent stock number to facilitate ordering. Special order blanks are also provided. This catalog will be of interest not only to teachers, supervisors, administrators, and school board members, but also to parents, students, and all others concerned with education.

Hilda Maehling Fellowship

The Department of Classroom Teachers will name the first Hilda Maehling Fellow during the 1961 NEA Convention. Applications for fellowship are due by December 1. The Fellowship program was established in 1959 to pay tribute to Hilda Maehling, first executive secretary of the Department of Classroom Teachers and first assistant executive secretary for professional development and welfare of the NEA. Applications and information may be obtained from the Hilda Maehling Fellowship Committee, NEA Department of Classroom Teachers, 1201 Sixteenth St., N.W., Washington 6, D.C.

THE PLASM

RECENT developments in physical sciences and technology have brought about a great need for research and other operations at extremely high temperatures. In order to fill this need, methods have to be found for the generation of high temperatures and the high-temperature properties of matter have to be investigated.

The interest in highly refractory solids has given rise to experiments at temperatures between 2000° and 4000° C. New heating devices and new measuring techniques, based mainly on thermal radiation, are being developed for this purpose.

As the temperature range increases, so do the difficulties of operation. Above 4000° C entirely new fundamental considerations are required before experiments can be planned and carried out. In this temperature range, every substance known today is in a gaseous state at one atmosphere pressure. Since gases are mostly transparent to thermal radiation in that temperature range, other principles have to be found and applied to the problems of heating them to and making observations on them at extremely high temperatures. In order to find the most suitable principles, some of the fundamental properties of gases at high temperatures have to be considered.

The Behavior of Gases at High Temperatures

The particles of a gas are constantly in a state of translational motion above absolute zero. The average velocity C of the particles is given by the equation:

$$C = \sqrt{\frac{2RT}{M}}$$

where R is the universal gas constant, T the absolute temperature, and M the molecular weight. It is important to note that the velocity increases at a slower rate than the temperature.

The translational motion results in collisions between the particles. At moderate temperatures, the collisions are essentially elastic, *i.e.,* no loss in total kinetic energy occurs. As the temperature increases, the particles "soften up" and some collisions become inelastic. A portion of the translational energy is taken up by the particles in the form of internal (rotational, vibrational, electronic) energy.

The changes occurring in diatomic gases as a result of increasing temperatures are summarized in Table I, using nitrogen as an example. At 2000° C the translational energy has increased considerably, but the collisions are still completely elastic. At 7000° C the translational energy is further increased, but because of the violent motion, the gas molecules begin to dissociate. (Thermal dissociation.) Approximately one-third of the molecules are dissociated into nitrogen atoms at that temperature. Some of the valence electrons are in an excited state and, as a consequence, emit radiation by returning to their original state; the gas is therefore luminous. About one per cent of the outer electrons are separated

By TIBOR S. LASZLO

Senior Staff Scientist, Research and Advanced Development Division,
Avco Corporation, Wilmington, Massachusetts

from the atoms, and accordingly there are some nitrogen ions present. The concentration of the free electrons, however, is not high enough to make the gas a good electrical conductor. At 12,000° C the thermal dissociation is essentially complete; there are virtually no molecules present. Many of the outer electrons are in an excited state, and the gas is very luminous. About 15 per cent of the electrons are freed from the atom, making the gas a very weak conductor of electricity. The concentration of nitrogen ions is increased. At 20,000° C the degree of ionization is 30 per cent, and in addition to the singly charged nitrogen ions, there are already some doubly charged ions. The electrical conductivity is high. The degree of ionization at 30,000° C is 60 per cent. Thus half of the nitrogen ions are doubly ionized, and due to the high concentration of free electrons, the electrical conductivity of the gas is extremely high.

When the temperature increases to a hundred million degrees, the atoms break completely apart. There are none of the above ions present, only free electrons and nuclei stripped of electrons. The electrical conductivity of the gas is comparable to that of copper at ambient temperature.

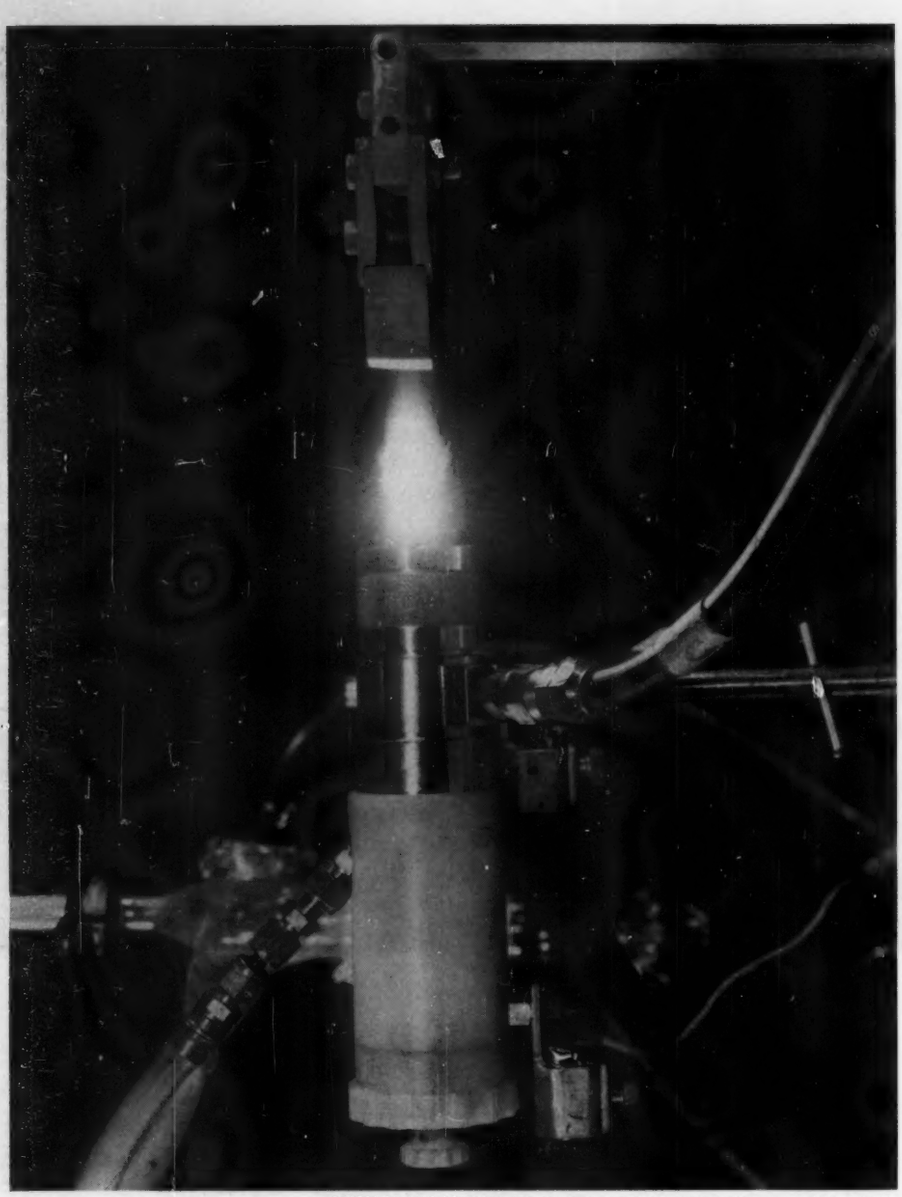
The Magnetohydrodynamic Principles

The ionized gas is called a plasma. The plasma consists of free electrons and ions in charge equilibrium. It is electrically neutral, but it conducts electricity. This electromagnetic property is the most important difference between plasmas and ordinary gases. The science which is concerned with the dynamics of plasmas and conducting liquids in an electromagnetic field is called magnetohydrodynamics. The plasma can be considered the fourth state of matter, following the solids, liquids, and gases. It is interesting to note that Aristotle defined four states of matter: earth, water, air, and fire. It is very tempting to equate earth with solids, water with liquids, air with gases, and fire with plasmas.

The application of the principles of magnetohydrodynamics to several problems already has yielded some important results in the fields of fundamental science and technology.

The Origin of Solar Systems

A very interesting application of magnetohydrodynamics is in a new theory on the origin of the solar system. The presently accepted theory, based on ordinary hydrodynamics, proposes that the planets of the Sun condensed out of gases which moved under the action of gravitation and other purely mechanical forces. This



PHOTOS BY AVCO RESEARCH AND ADVANCED DEVELOPMENT DIVISION, WILMINGTON, MASS.

FIGURE 1. Small plasma generator spraying alumina on an aluminum block.

theory fails to explain, among other things, the regularity of the solar systems, the number and size of planets, their distances from the Sun, etc.

Most recently a new theory has been proposed by H. Alfven, based on magnetohydrodynamics. According to this theory, the magnetic field in interstellar space is strong enough to require application of magnetohydrodynamics in the theory of stellar evaluation. The Sun is considered to have condensed from plasma and some of the magnetized gas cloud to have been left over at great distances from it. Since the Sun possessed a strong magnetic field, the completely ionized gas (plasma) could not fall freely toward the Sun under the influence of gravity.

As the plasma began to cool, the atoms with the highest ionization potential were the first to become deionized. These atoms began to fall toward the Sun under the influence of gravity, whereas the still ionized part of the gas cloud was kept away. The falling de-ionized gas collided with the ionized gas layer which always surrounds the Sun. The kinetic energy of the falling gas was high enough to make the collisions inelastic. As a consequence, the kinetic energy of the falling gas was absorbed and the gas became ionized. In this plasma state, the gas was stopped in its fall by the electromagnetic field of the Sun. The distance at which the plasma stopped, was then determined by its kinetic energy which in turn might be defined by the distance it had fallen from its original position.

The still ionized part of the original plasma cooled further, and as a consequence, a second group of atoms with a lower ionization potential became deionized, started to fall towards the Sun, etc. This process was repeated until the Sun became covered with several layers of plasma.

The plasma layers rotated around the rotating Sun because of electromagnetic interaction. As the plasma cloud cooled, some of the elements condensed into dust particles. These solid particles orbited around the Sun and in time aggregated, forming the planets. The formation of the planetary satellites can be explained by a similar process, substituting the planet for the Sun.

This very recent theory, although not yet generally accepted, appears to explain satisfactorily the formation of the solar system. Further, the theory makes it appear likely that other stars, which are similar in magnitude to the Sun, have a planetary system similar in size, distance, chemical composition, etc., to our solar system. The next logical step in this theory could be that surface conditions on these planets are also similar, and therefore a planet which corresponds to the Earth in another solar system may have life upon it as we know it on Earth.

The Plasma in Controlled Fusion Reactions

The best-known application of magnetohydrodynamics is in experiments to control fusion reactions. The starting step in all such experiments is the generation of a high-temperature plasma. The plasma is further heated to such high temperatures (10^8 degrees) that it contains free nuclei. At this high temperature, the nuclei collide with such high velocity that nuclear repulsive forces are overcome, and the nuclei may get close enough to each other for fusion to take place.

The technical difficulties in achieving controlled-fusion reactions are very great. The high-temperature plasma has to be contained in such a manner that it should not come in contact with the walls of the container. Should this happen, not only would the container

immediately vaporize, but the plasma would cool off considerably. Since the plasma is electromagnetic, strong magnetic fields are used to contain it. This gives rise to further troubles from instability. A small inhomogeneity may compress the plasma more at one point than at others. With the magnetic susceptibility thus increased, the compression rapidly increases until the plasma is "pinched" and its continuity interrupted. Another observed trouble is that the plasma does not stay quiescent in the center of the magnetic field; it wiggles. During this motion, it may touch the container destroying it and itself. Several approaches are being pursued to control these phenomena.

TABLE I

N_2 Gas

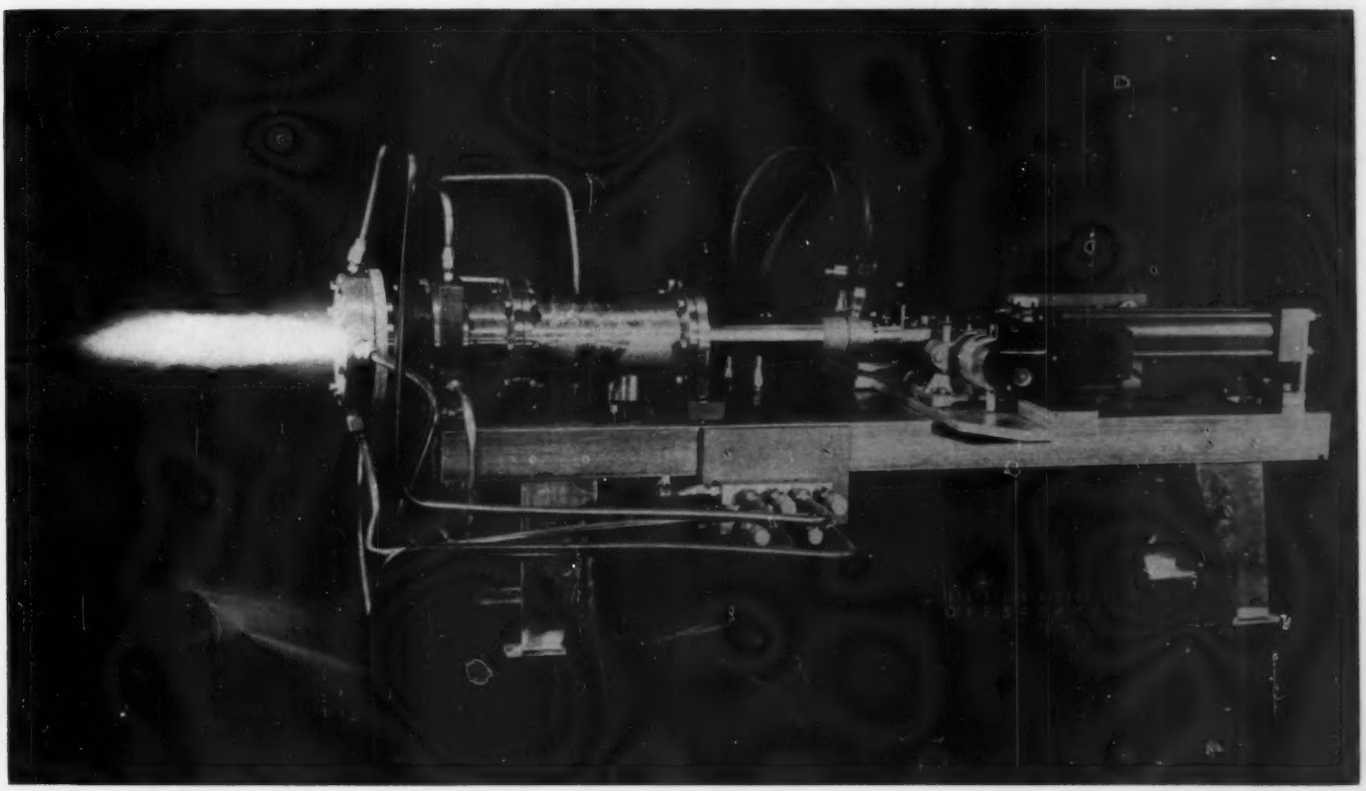
°K	*Thermal Diss.* $N_2 \rightarrow N$	*Radiation Exc. Elec.*	*Ionization Free Elec.*	*Electr. Conduct.*	N^+	N^{++}	*Free Nuclei*
2,000	—	—	—	—	—	—	—
7,000	1/3	yes	1%	no	yes	no	—
12,000	compl.	yes	15%	slight	yes	no	—
20,000	compl.	yes	30%	strong	yes	yes	—
30,000	—	yes	60%	very strong	50%	50%	—
10^8	—	yes	100%	primary	0	0	100%

The Magnetohydrodynamic (MHD) Electric Power Generator

Another possible application of the plasma is in the conversion of heat to electricity. The presently used cycle, fuel-steam-turbine-generator, has a very low thermal efficiency, and many attempts have been made to shorten this cycle. In a conventional generator, electricity is obtained by moving a solid conductor (a copper coil) in relation to a (stationary) magnetic field by steam turbine power. Now, if the copper coil is replaced by a plasma which moves through a stationary magnetic field, the conditions necessary to induce an electric current are fulfilled. In the magnetohydrodyamic generator the fuel is burned under conditions which will yield very high-temperature combustion gases. These gases (seeded with 0.1 per cent potassium to increase electrical conductivity) pass through a magnetic field. Stationary electrodes are inserted into the plasma to conduct away the generated electricity. These electrodes perform the same function as the carbon brushes in a conventional generator.

In at least two laboratories in the United States, electricity is already being obtained on experimental magnetohydrodynamic generators. Many

FIGURE 2. High-enthalpy arc, using graphite electrodes.



engineering problems have to be solved before a unit of practical size can be built. It is estimated, however, that when such a unit becomes operational, its efficiency may be 25 per cent higher than that of presently available power plants.

Plasma Generators

The development of plasma generators has advanced considerably during the last few years. These generators are based on the principle of the electric arc. In a conventional or low intensity carbon arc, two carbon electrodes are connected to a power supply, brought in contact momentarily, and then separated. The air gap between the two electrodes is bridged by an arc of high luminosity. During this process, the negative electrode, the cathode, emits electrons which are accelerated by the plasma in the arc and reach the anode. The carbon does not heat up to vaporization temperature. The consumption of the electrodes is due entirely to the oxidation of carbon in air. The current density at the anode is approximately 40 amp/cm^2. If more current is forced into the electrode, the current density does not increase, but the arc spreads out and occupies a larger area of the anode so that the original current density is maintained. During this process, the electrons and the ions, which travel in the opposite direction, are carried by the air since there is little carbon vapor in the plasma.

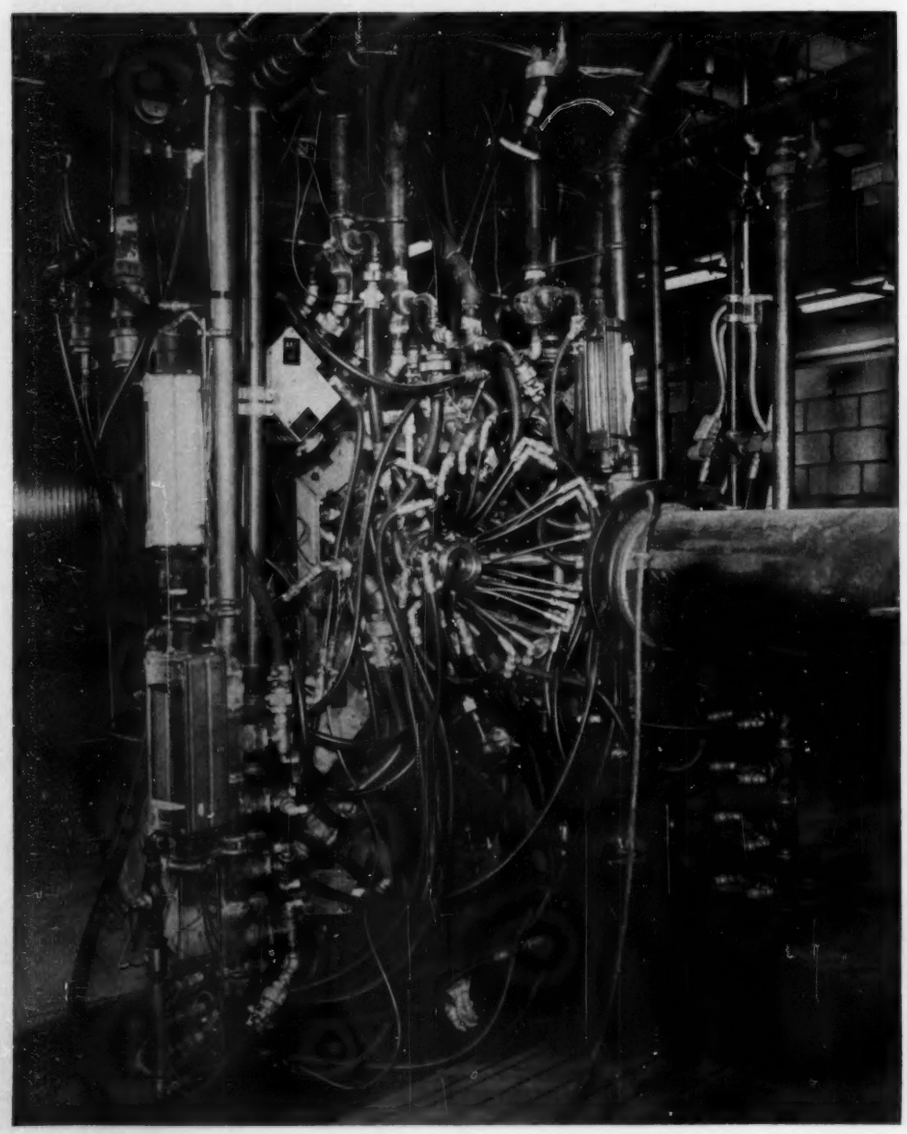
Another type of arc is obtained when the current density reaches 100 amp/cm^2, and sudden changes in behavior appear. The carbon surface reaches vaporization temperature, and the current is carried by carbon vapors. The plasma becomes highly electromagnetic, and its temperature increases considerably. The electromagnetic effect constricts the plasma into a narrow stream thus further increasing current density. It is possible to reach 5000 amp/cm^2 at the anode surface. Such an arc is called a high-intensity stabilized arc. Since a large number of electrons are in a highly excited state, the plasma is very brilliant from radiant emission.

The prevention of the arc from spreading on the anode surface or stabilization of the arc can be achieved by surrounding the cathode with a high-velocity, high-pressure gas. The first high-intensity arcs used water, which was fed tangentially into the arc chamber. Contact with the water confined and stabilized the arc. More recently, gases (air, nitrogen, helium, argon, etc.) have been used in plasma generators. In all cases, consideration has to be given to possible interactions between electrodes and the gas. Resulting contamination of the plasma may be a problem for some applications. Carbon electrodes can be replaced by copper, tungsten, or other refractory conductors to reduce contamination. Metallic electrodes may be cooled by water, to further reduce their consumption.

Several plasma generators are already commercially available. Small units (Figure 1) are used for spraying, cutting, and vaporizing highly refractory materials. Larger units (Figure 2) are used in laboratories for the study of high temperature properties of matter. Very large units are built (Figure 3) which can simulate the high temperature conditions missiles are exposed to when re-entering the Earth's atmosphere. Studies are being carried out on the application of plasma generators as space propulsion power plants.

In all the existing and future applications, the three fundamental properties of plasma are made use of: electromagnetism, high temperature, and high velocity. These unique properties make it very likely that the application of the plasma will solve many important problems in the future.

FIGURE 3. Ten megawatt plasma-generating facility with turbulent pipe-test section attached.

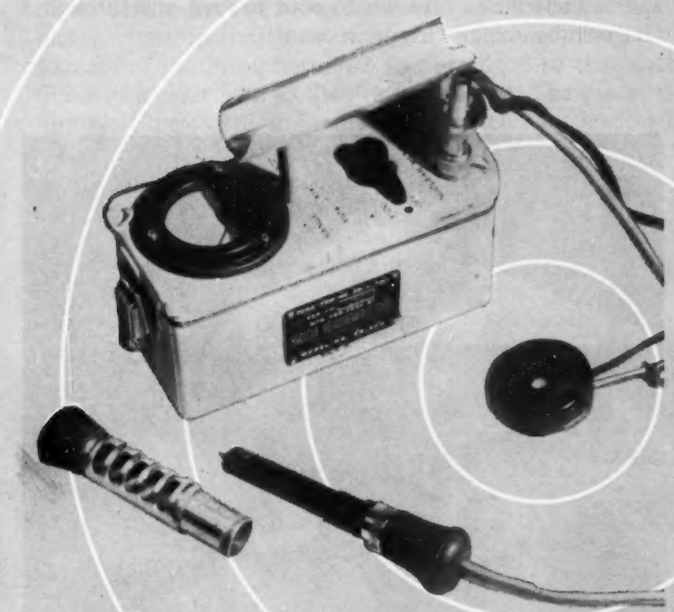


Low Level Radioisotope Techniques

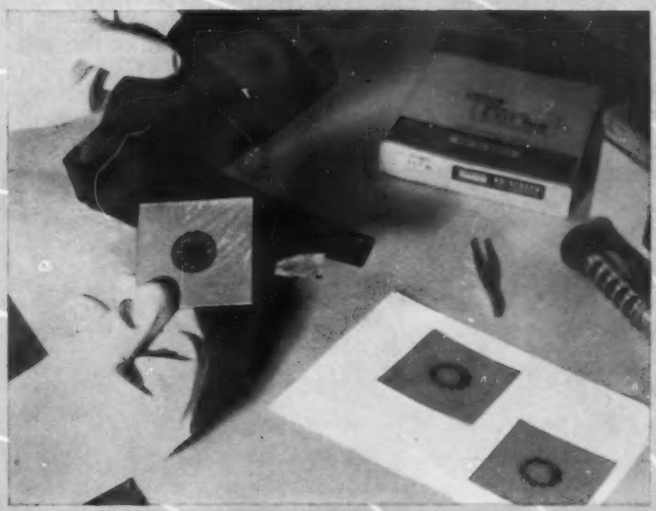
By JOHN H. WOODBURN

Chemistry Teacher, Walter Johnson High School, Bethesda, Maryland

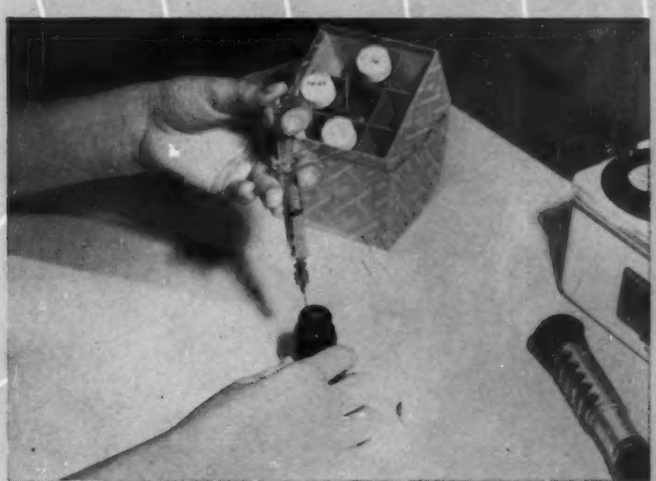
INCREASINGLY, more of us need to learn and understand as much as possible about nuclear phenomena. Simple experiments with low-level quantities of isotopes become one of the most interesting and informative ways in which nuclear phenomena may be understood. The following picture presentation describes a variety of methods and techniques whereby experiments can be accomplished to give students and teachers an excellent introduction to achieve this knowledge.



1. The Geiger counter is the instrument most commonly used for keeping track of nuclear radiations. The heart of the instrument is a relatively long, thin-walled tube, illustrated with its protective shield removed. The instrument will respond to any whizzing particles or bundles of energy which can penetrate or dislodge other ionized particles from the walls of the tube. Inside the instrument case, electronic circuits amplify each pulse that is triggered by a radioactive particle. Some instruments are equipped with recording devices to count the number of particles entering the Geiger tube over a period of time. In this instrument, however, counts must be made by observing the swing of a needle across a dial or counting the clicks which come over an earphone.

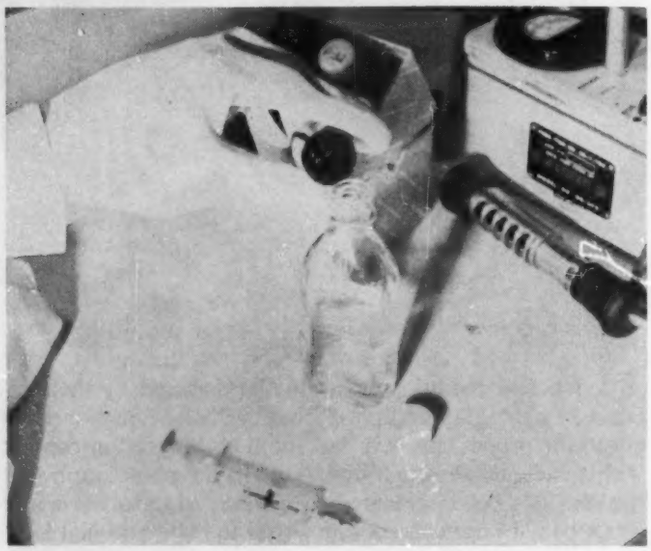


2. Nuclear radiations can also be detected by their effects on photographic film. Pieces of X-ray film are being cut to the proper size in a darkroom and placed in contact with a radioactive watch dial. Note in the photograph that the dial has been cemented to a piece of cardboard and wrapped with transparent film. After the film and dial have been wrapped with opaque paper, the preparation can be held down by two or three books and left long enough to expose the X-ray film. This photograph shows two pieces of film, one left in contact with the watch dial for three hours, and the other for one hour after being removed from the wrapping and developed. Developing procedures vary with different kinds of film, but, in general, the procedure is to leave the film in the developer for five minutes, in the fixing solution for ten, and in the washing liquid for thirty minutes.

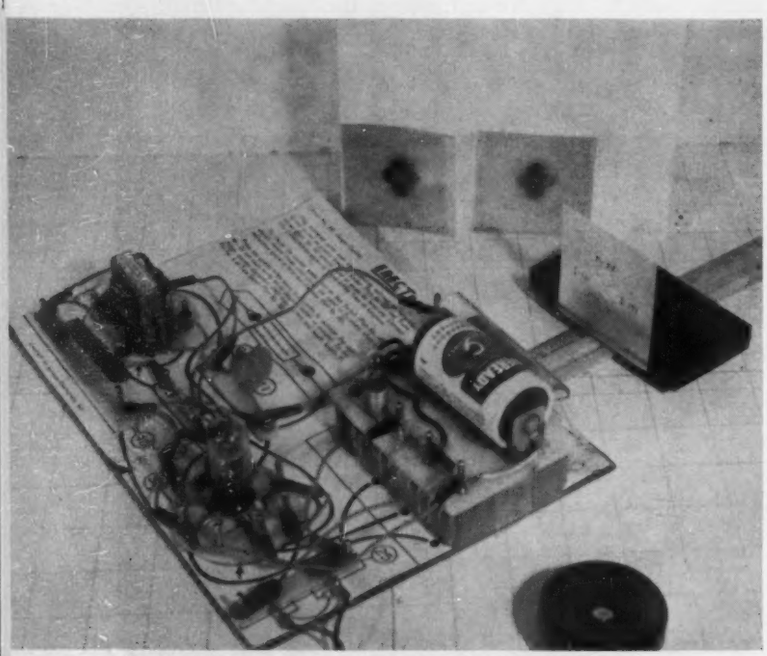


3(a). Laboratories which sell radioactive materials usually prefer to deliver the material as evaporated residues in small bottles. If 10 microcuries of Iodine 131 are ordered, for example, a small bottle will arrive which, from all appearances, will be empty. On the bottom of the bottle, however, there will be enough sodium iodide to contain so many Iodine 131 atoms that 370,000 of them will disintegrate each second. If 10 ml of water are added to the

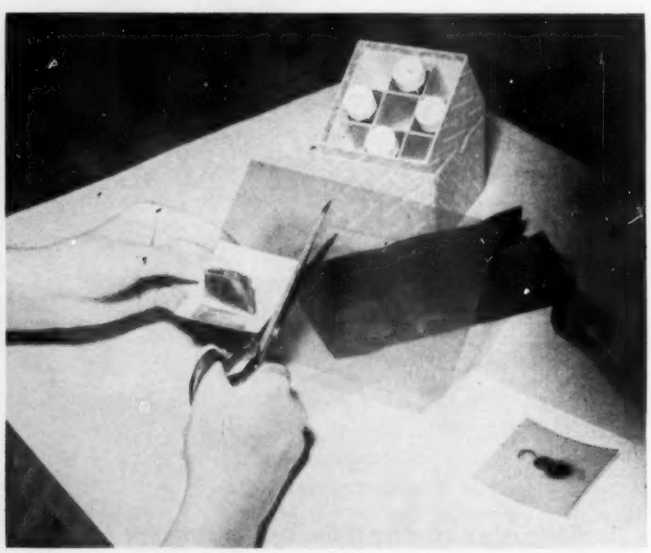
bottle, the sodium iodide will be dissolved, and 10 ml of Iodine 131 solution will be available. Each ml of this solution will contain one microcurie of Iodine 131.



3(b). If the supplier provides 50 microcuries of an isotope, Sulfur 35 for example, by washing five 10-ml quantities of water from the delivery bottle, 50 ml of Sulfur 35 solution will be available. Each ml of this solution will also contain one microcurie of Sulfur 35.

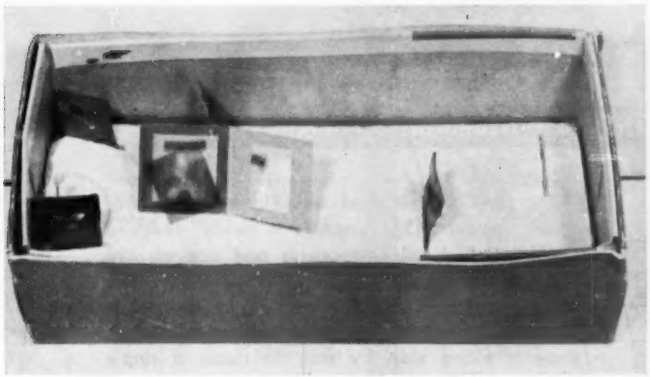


4. A convenient way to handle small quantities of radioisotopes in the dry form is to transfer a few drops of the one microcurie per ml solutions to circles or squares of filter paper, dry, cement on a tagboard card, label the card with the name of the isotope and the date prepared, and wrap the card with transparent film. Shown is a card made up with two paper discs, each of Phosphorus 32 and Iodine 131. This card gives you the key to the relationship between the number of counts recorded by a Geiger counter and the distance the source is from the counter. Also, by combining two isotopes on one card an interesting problem in half-life decay rates is obtained. Iodine 131 has a half life of eight days, whereas Phosphorus has a half life of approximately fourteen days. By exposing the paper discs to X-ray film when the isotopes are fresh and then repeating the procedure at eight-day intervals or more, the effect of half-life decay is clearly evident. The counts obtained against time can be graphed, and the resultant decay-rate curves analyzed from the four combined discs. Thus, the isotopes being used and their half lives are known, but it is unlikely that the half lives as observed will agree with generally accepted quantities. Extremely accurate observations must be taken if one is to identify an isotope by observing its half life and then checking it against a standard table of half lives. In interpreting data, it must be remembered that the beta particles from Phosphorus 32 are more likely to reach and trigger a count in the Geiger counter than are the lower energy particles from the Iodine 131. Furthermore, when an Iodine 131 atom disintegrates, it emits a beta particle and a gamma ray. The gamma ray travels through greater thicknesses of air and other materials before expending its energy, but only a very small percentage of the gamma rays which whiz toward and through a Geiger tube actually trigger a count.

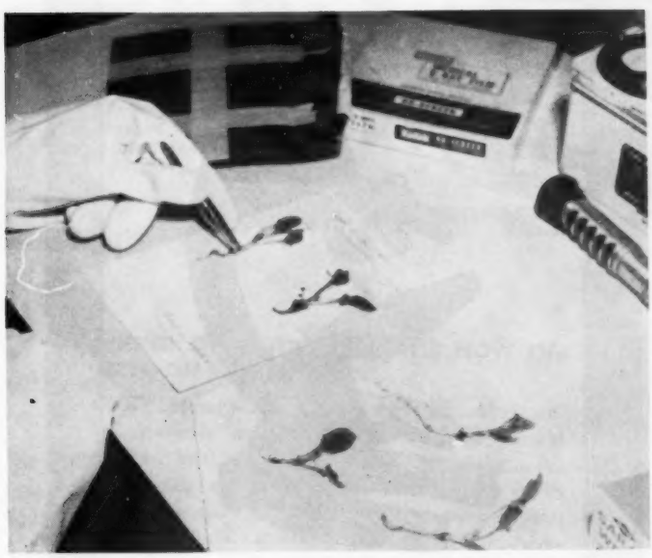


5. To compare the energy of the radiations from Sulfur 35, Iodine 131, Phosphorus 32, and Zinc 65, paper discs were soaked in one microcurie per ml solutions of these isotopes, dried, cemented to a 2¼- x 2¼-inch piece of tagboard, and wrapped with transparent film. The discs were then soaked with a pack of sheets of aluminum foil or lead foil arranged so that the top edges of the discs were not covered, but the nuclear radiations coming from the discs would encounter increasing numbers of sheets of foil further down the paper discs. The preparation was then covered with X-ray film and left in opaque paper wrappings inside a heavy book for approximately fifteen hours. The

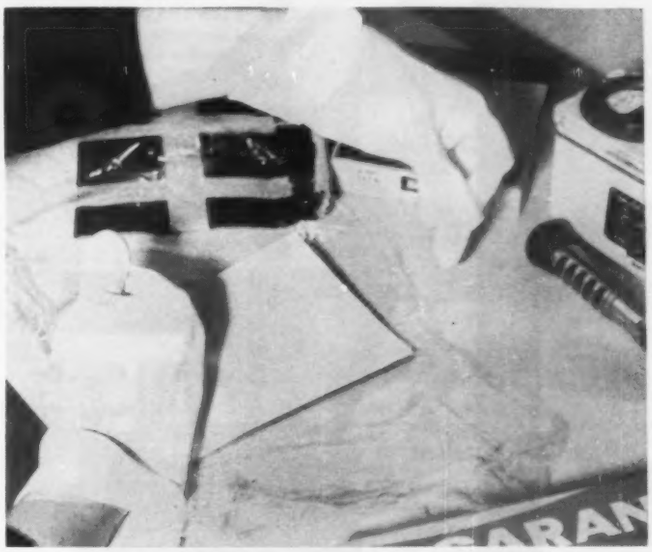
developed films will show the relative abilities of the radiations to pass through increasing thicknesses of whatever metal is used. Shown here are the results obtained when using sheets of aluminum foil.



6. To observe how atomic radiations lose their energy and scatter out as they pass through increasing distances is another interesting exercise. In the box above is seen a small ball of cotton that soaked up a few drops of the one microcurie per ml Phosphorus 32 solution and was mounted on a toothpick in the end of a box. In the darkroom, small pieces of X-ray film were placed one inch, two inches, four inches, and eight inches from the "point source" of the Phosphorus 32 and arranged so that each film had a clear path to the Phosphorus 32. The pieces of film were protected from the beta particles by lead, but three holes were placed in the lead shields. Shown is one of the pieces of film after it had been in the light-proof box for approximately 120 hours. The film has been developed, fixed, washed, dried, and is ready for mounting in a 2- x 2-inch slide binder so that it can be projected for study.



7(a). A satisfactory procedure for making plant autoradiographs is shown in this series of photographs. After the experimental plants have been removed from whatever radioactive solutions were involved in an experiment, they are rinsed clean, blotted dry, and carefully placed on labeled tagboard cards. Note use of the rubber gloves. Unless a specific experiment dictates which plant should be used, small, vigorous weeds can be substituted. They should, of course, be checked to see if they have already absorbed a radioactive material. This can be done by using the procedure below (b) and exposing the "control" specimens to X-ray film for a much longer time than will be required for any experimental plants.



7(b). A solution to the wrapping problem is now suggested. A heavy cardboard has been placed on top of the plastic film-covered plants to hold them in place while the preparation is turned upside down and the film is tightly stretched, folded, and secured on the underside of the plant material card.

7(c). This is the final preparation. The transparent film protects the plant specimens, yet introduces a minimum of shielding between the photographic film and the radiations coming from the plant. It also prevents transfer of radioactive materials, an important safety precaution.

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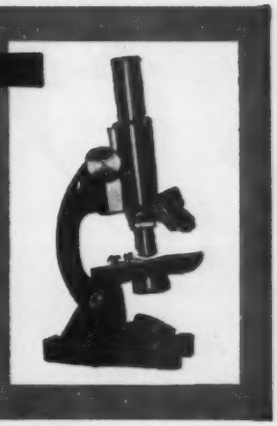

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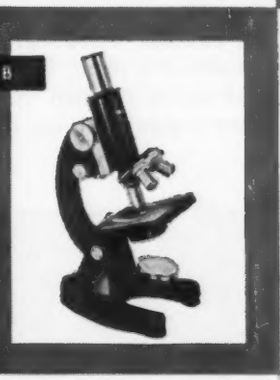

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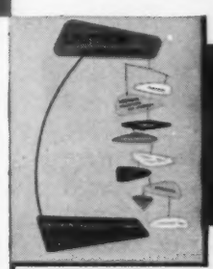

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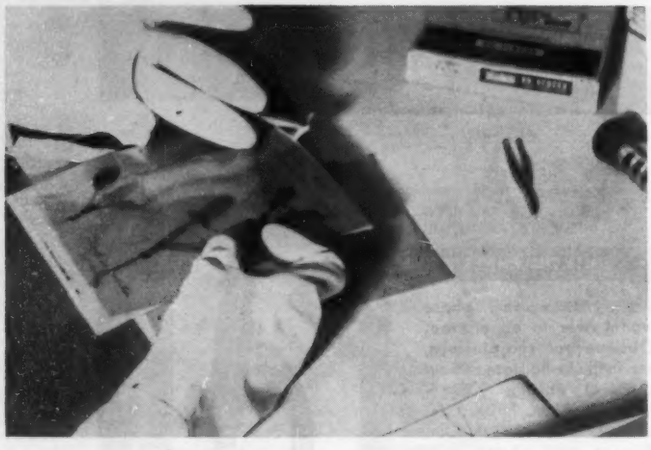
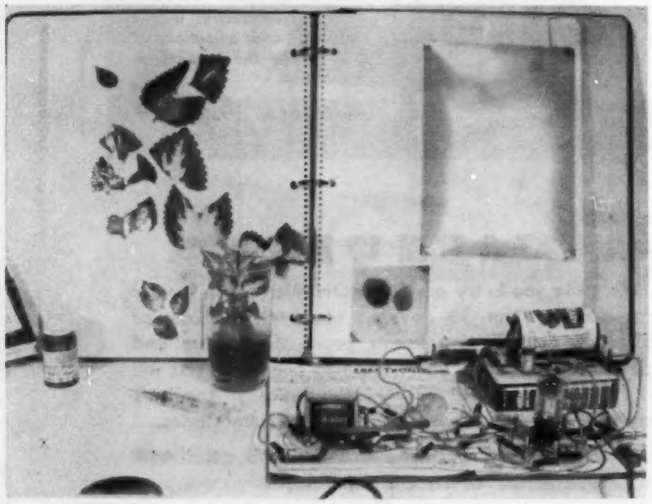
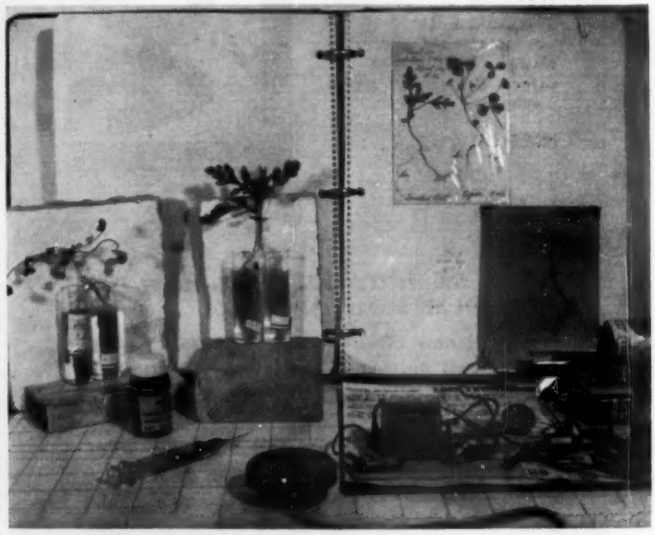


7(d). Shown is the plant preparation being covered with X-ray film and inserted in a light-proof envelope. This step, of course, must be done in a darkroom. The envelope will now be weighted by several books to insure uniform contact between the plant materials and the X-ray film. One ml of the one microcurie per ml radioactive solutions is usually adequate for all tracer exercises. This assumes that plants less than a few inches in length are used which require no more than 10 to 30 ml of total diluted solutions.



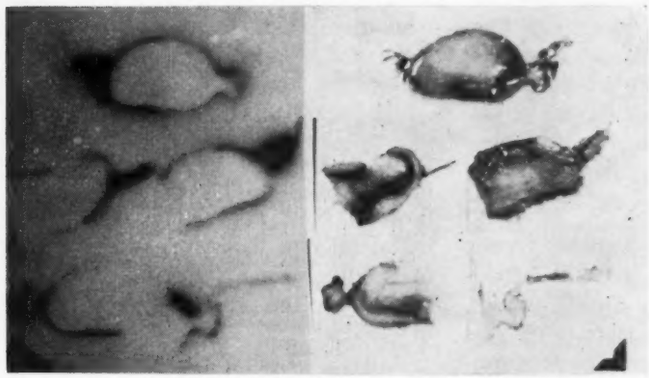
8. Are plants more or less likely to deposit Phosphorus in green portions of leaves rather than in colorless portions? To study this question, a plant with varicolored leaves was placed in 30 ml of water which contained one ml of one microcurie per ml Phosphorus 32. Invidiual leaves were removed after one, two, three, four, and five hours, placed on tagboard, wrapped with transparent film, and inserted in light-proof envelopes with X-ray film. No deposit of Phosphorus 32 was observed in this preparation. After the plant had been in the radioactive solution a longer period of time, however, newly formed leaves showed uptake of Phosphorus 32, but no difference between green and white leaf tissue was observed. It will be interesting to try this same experiment with isotopes of other elements and to vary light, temperature, and similar conditions under which the plants are being grown.

9. Do different species of plants vary in the amount of radioactive Sulfur 35 and Iodine 131 they will absorb from the same solution? Six different species of plants were placed in 20 ml of water containing one ml of one microcurie per ml of Sulfur 35 or Iodine 131. The accompanying autoradiographs show relative absorption of each of the species after they had been in the solutions for twenty-nine hours. It is very difficult, however, to gain quantitative data from autoradiographs. The beta particles from Sulfur 35, for example, have scarcely enough energy to penetrate the tissues of a plant, whereas the radiations from the Iodine 131 which reached the X-ray film may have come from deep within the plant tissues.

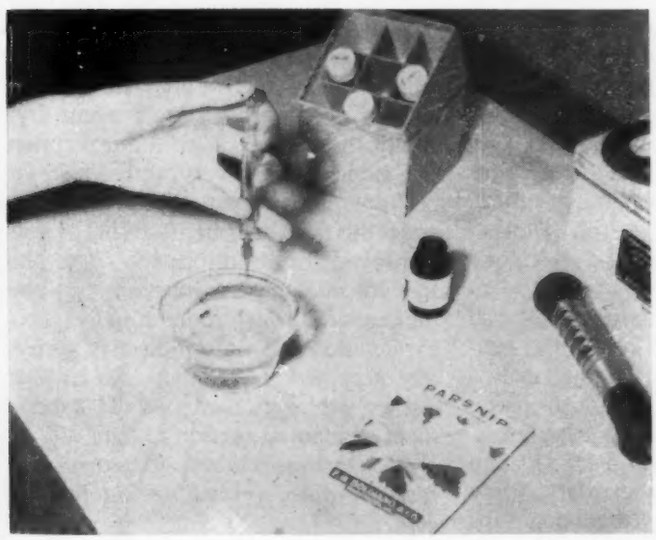


10. Do minerals only move upward in plant roots? To test this hypothesis, the root systems of two plants were divided as shown in tubes placed side by side. One-half of

the root system of a clover and ragweed plant was placed in solutions containing Phosphorus 32; the other half of the root system was in ordinary water. The radioactive solutions contained 0.2 ml of the one microcurie per ml solution of Phosphorus 32. After the plants had been in the solution seven hours, they were removed and autoradiographed. The autoradiographs on the right show that there is some movement of the radioactive Phosphorus down through the portion of the root system that was not in the radioactive solution. Other investigators may want to determine whether the movement occurred on the outer surface of the root or whether it occurred within the usual conducting tissues of the root.

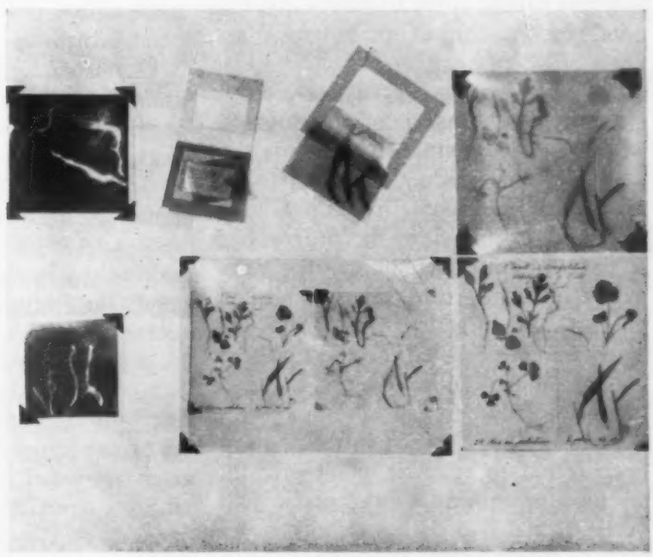


11. A sprouting dahlia tuber was left for 157 hours in 20 ml of water containing one ml of one microcurie per ml Phosphorus 32. Slices of the dahlia tuber were then wrapped with transparent film and placed in contact with X-ray film for ten hours. The illustrated autoradiographs show the portions of the dahlia tuber which absorbed radioactive Phosphorus.



12(a). Tracer isotopes can be used to find out many interesting things about what goes on in seeds when they germinate and develop into seedling plants. A convenient procedure is to float thin sponge discs on water in small dishes or beakers. Seeds can be "planted" on the sponge. One ml of one microcurie per ml solution of Phosphorus 32 is being used for the tracer isotope. If seeds are added at approximately five-day intervals, they can all be removed after the oldest have formed seedlings, been washed briefly, partially dried, placed on tagboard cards, labeled, covered with X-ray film, wrapped with opaque paper, and weighted. After ten to twenty hours the X-ray film can be developed. Autoradiographs will thus show when and how much radioactive material was absorbed during germination and growth of the seedlings.

12(b). A thought-provoking observation is the nonuniform absorbtion of Sulfur 35. Note the small pockets appearing in the tomato seedlings of this autoradiograph. Why they appear becomes a question for another investigation—and this is the fascination of these experiments.



13. Autoradiographs can be studied or exhibited in their natural state, printed in a photographic enlargement, printed contact, bound and projected as either 2- x 2-inch or "jumbo" lantern slides, or photographed against a white background. When appropriate, the preparation from which the corresponding autoradiograph was made could also be included.

The Regulation of Plant Growth

By ROBERT W. STEGNER

Science Teacher, East High School, Denver, Colorado

This report was an entry in the 1960 STAR (Science Teacher Achievement Recognition) awards program conducted by NSTA and sponsored by the National Cancer Institute, U. S. Public Health Service.

MANY teachers of high school biology will agree that plant science is more difficult to teach to make it interesting than many other phases of biology. Yet, no part of biology is more important, and teachers should strive to enrich and expand presentations of the botanical aspects of biology.

Thinking people everywhere are beginning to see that man's population will someday completely outstrip the world's food production in spite of temporary surpluses in the United States. With this view, the progress of recent years in understanding the basic nature of plant growth takes on special interest and urgency. The following activities are designed to develop these understandings more deeply in high school biology classes.

Among the chemicals which have been found to regulate plant growth, the most prominent is indoleacetic acid or IAA, which occurs naturally in all higher plants and is hormonal in action. This substance is now being produced commercially and lends itself to use by high school students.

Many home owners are acquainted with 2,4-D (2,4-dichlorophenoxyacetic acid) and its ability to kill broad-leaved weeds without harming grasses. Actually, at low concentrations this substance acts as a plant growth stimulant. It is a synthetic substance chemically related to IAA. Numerous other synthetic substances influence plant growth, but herein we will discuss only IAA since it occurs naturally in plants and has been shown to regulate to some extent practically every phase of plant growth.

I. *The extraction of IAA from corn grains and demonstration of its growth-promoting action on sunflower seedlings.*

Grind about 25 sweetcorn grains in a mortar and place meal in a small beaker. Add 10 ml of 1/50 Normal sodium hydroxide solution and boil gently for 5 minutes while stirring, thus releasing the IAA from the cornmeal. Now cool and neutralize with 10 ml of 1/50 Normal hydrochloric acid and filter through cloth. Melt a teaspoonful of anhydrous lanolin in a small dish over hot water, add 5 ml of the neutralized corn extract to the melted lanolin, and mix to a whitish paste. Prepare a control paste by using a teaspoonful of lanolin with 5 ml of plain water instead of corn extract. Apply these two preparations to two groups of sunflower seedlings about 8 to 12 days old. The seedlings should be about 3 inches tall (the straighter the better). They can be placed in the dark the day before use to insure straight plants. (To grow these seedlings, use the seeds of the large, ornamental sunflower.) Now apply the IAA lanolin unilaterally to the stems of one group of seedlings and the control lanolin similarly to the others. Place all plants in the dark.

After 24 hours, the extracted hormone should cause the stems of the treated seedlings to curve because of the increased growth on the treated side. The control group should remain straight.

This same experiment can be done by saturating 1½-inch strips of absorbent cotton in the corn extract (no lanolin) and pinning them to the seedling stem with a slender pin thrust through the seedling leaves. The controls would use cotton soaked in plain water. In this variation, it is necessary to keep the plants well covered with a bell jar or other device to prevent drying of the cotton. With that exception the method works very well.

Apparently, when a plant turns toward the light, it is because the IAA is destroyed or translocated from the lighted side of the stem so that the darker side grows more rapidly. This explanation of phototropism is generally accepted. Here, then, we have a deeper explanation of our old experiment of plant attraction to light.

II. Demonstrations of growth effects of pure, crystalline indoleacetic acid.

A. Effects on cell elongation.

Preparation of Solutions: Weigh out 10 mg of crystalline indoleacetic acid

NOTE: The author will teach at Washington High School, Denver, Colorado, in the fall of 1960.

and dissolve in 2 or 3 ml of ethyl alcohol. Pour the resulting solution with rapid stirring into 100 ml of water and warm the mixture gently to evaporate the alcohol. Dissolve 2 g of sucrose in water to make 100 ml and place 18 ml of this solution in each of five Petri dishes. With a pipette, add 2 ml of the IAA solution (prepared above) to the first dish to make a concentration of 10 parts per million of IAA (parts per million equals milligrams per liter). *Stir* this solution thoroughly and take 2 ml for the second dish, making a solution of 1 ppm. *Stir*. Take 2 ml from the second dish and add to the third to make a concentration of 0.1 ppm. *Stir*. Take 2 ml from the third and add to the fourth dish to make 0.01 ppm. Leave the fifth dish with distilled water as a control.

Procedure: Hull several hundred oat grains or use wheat grains that have already been threshed from their hulls. Soak them for 5 hours in pure water and then plant in shallow containers of moist soil or sand. Do this with care to be sure of a uniform crop of leaf sheaths or coleoptiles. Place each grain pointed end downward in a small hole of a depth just exceeding the length of the grain. Firm the soil with the fingers.

When the coleoptiles are about 25 to 30 mm long—the fourth day at 25° C—bring them out into the light and carefully cut them off at the base. (See Figure 1 herein.) Lay several coleoptiles side-by-side with their tips in line and cut uniform sections from them by using a cutter as pictured. The cutter is made with two double-edged razor blades fastened to the two sides of a small block of wood about ¼-inch thick, as a double-bladed knife (Figure 2). For this experiment you will need 50 sections. As soon as they are cut, float them in distilled water. Place ten sections in each of five Petri dishes containing concentrations of 0.0, 0.01, 0.1, 1.0, and 10.0 parts per million of indoleacetic acid in sugar (sucrose) solution.

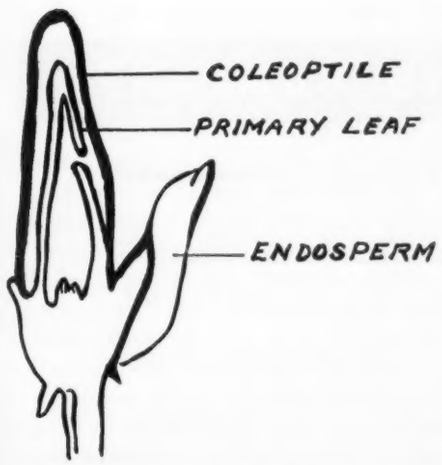


FIGURE 1. Oat seedling.

Place the dishes with their coleoptile sections in the dark at about 25° C for approximately 24 hours. Then bring dishes out into the light and measure the coleoptile sections to the nearest half millimeter. Calculate the average length in each dish and the average increase in length. Plot the data on a graph with the average-increase-in-section length on the vertical axis and the hormone concentration equally spaced on the horizontal axis.

The graph will show an increase in growth with increasing concentrations of IAA up to a point after which an inhibition of growth appears. The growth which is induced in the sections by the IAA is due to cell elongation rather than increased cell division.

This technique can be used as a bioassay to indicate quantitatively the amount of growth-promoting substance present in a solution and is often more accurate than any chemical test.

B. Effects of IAA on the growth of lateral buds.

Procedure: The relatively large amounts of IAA produced by the growing tips (apical buds) move downward in the stem and inhibit the growth of the lower buds. This explains the lack of development of lateral buds of many plants and influences the habit of growth of plants, often determining whether they will be tall and slender or short and bushy. The growth of many flowering plants and other ornamentals can be regulated by "pinching-out" the apical buds.

To investigate this phenomenon, grow sunflower, bean, pea, or other seedlings in pots or flats until true leaves have appeared. Divide into three groups. Set aside Group 1 as a control. Remove the stem tips from the seedlings in Group 2 with a razor blade and apply pure, anhydrous lanolin to the cut surfaces. Also remove the stem tips from the Group 3 seedlings and apply

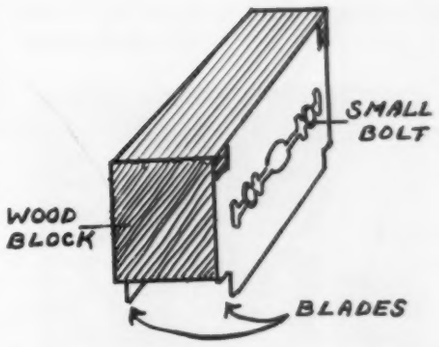


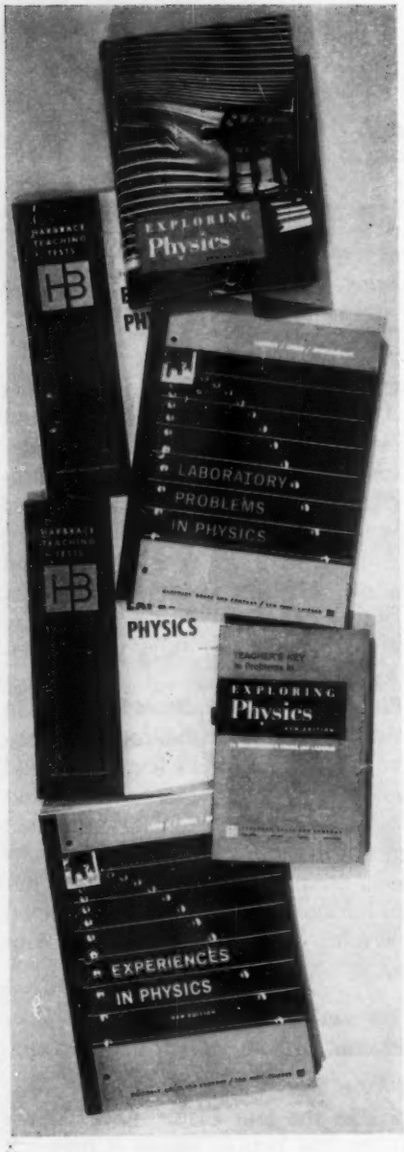
FIGURE 2. Coleoptile section cutter constructed of two double-edged razor blades fastened to a block of wood.

a dab of anhydrous lanolin containing IAA to each cut surface. An amount the size of a matchhead would be adequate. Prepare the IAA-lanolin mixture as follows: Weigh out 2 g of anhydrous lanolin. Dissolve 30 mg of IAA in 1 to 2 ml of ether or ethyl alcohol and *mix* with the lanolin. Warm mixture gently to drive off the ether or alcohol and allow to cool before use.

Place the three sets of plants in favorable growing conditions and observe for several weeks for lateral bud development. You can expect that buds will not develop in the untreated plants or in those treated with the IAA-lanolin mixture which replaces the natural hormone. Buds could be expected to develop in the stems treated with plain lanolin.

C. Prevention of leaf or petiole fall—abscission.

Procedure: Indoleacetic acid produced in the leaf blade moves down into the leaf petiole where it prevents the formation of a weak cell zone at the petiole base which would otherwise result in leaf fall. This phenomenon can be demonstrated quite easily with the *Coleus* plant. Leaving the petioles attached to the plant, remove a number of leaf blades with a razor blade. Place labeled, paper-reinforcement rings on the bases of these petioles and apply dabs of pure lanolin to half of the petioles and IAA-lanolin mixture to the other half. In a week or two you can expect that the lanolin-treated petioles will drop off in the normal fashion while those treated with IAA will remain on the stem as though the leaf blades were still there. This explains why deciduous trees lose their leaves in the fall whenever growing



To a student, physics should be more than just a description of *things* as discovered by geniuses; it is [an] aim of this text that the student should himself experience fundamental physics as a real and understandable growing body of exciting *ideas*. To this purpose we have devoted more space than usual to showing how major principles are deduced from basic experience, how these pervasive major principles enlarge our understanding of the physical world, and how, even as they add to our understanding, they raise new and still unanswered questions at the forefront of modern research—research that will be carried out by some of the students who use this book.

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conditions bring about a decline in hormone production.

D. Induction of rooting in plant cuttings by IAA.

Although many plant cuttings root readily when placed in moist sand, others root only slowly or not at all. Rooting of such cuttings can be accomplished or increased by the application of IAA to the cut surface or by setting the cuttings in IAA solutions. Cuttings from a variety of plants, such as lilac, rose, geranium, ivy, carnation, and others could be tried with suitable controls. Try soaking the cutting bases in a solution of 100 mg of IAA per liter for 24 hours. Then place the cuttings in moist sand and observe for the time needed for rooting and the number of roots produced. At the same time you might want to try a series of concentrations of IAA since the optimum concentration probably varies somewhat with the species. Lanolin pastes could be used also by applying the lanolin to the bases of the cuttings. This procedure has important implications for horticulture and perhaps for agriculture.

E. The induction of fruit formation without pollination (parthenocarpy) by treatment with IAA.

Procedure: Most fruits develop only after pollination of the flower. This development is apparently related to IAA content of the pollen and the induction of further IAA production. Exceptions are the natural formations of various seedless fruits. To investigate this phenomenon, select a tomato plant with unopened and unpollinated, but well-developed, flower buds. Open a bud and with a forceps remove the circle of unopened stamens and the petals, exposing the pistil. With a razor blade cut off the stigma and the upper part of the style and apply a dab of IAA-lanolin mixture to the cut surface. Treat several flowers and then repeat with another group of flowers and pure lanolin. Label all treated flowers and place plants under favorable growing conditions. The IAA-treated ovaries should develop fruit in a few weeks. Prepare IAA-lanolin as in part B.

This series of activities should give the student an elementary idea of recent advances in plant growth studies. A thorough understanding of the effects of chemicals such as IAA has great possibilities for influencing plant growth and food production. But, this is not the magic wand with which science will solve all of mankind's problems. Man's adjustment to earth-living must be considered from the viewpoints of production, conservation, and population. With such investigations as those described herein, scientists are working on one phase of the production problem. Students of biology should be exposed to this vital and fast-moving field of science and also to the whole matter of population versus resources.

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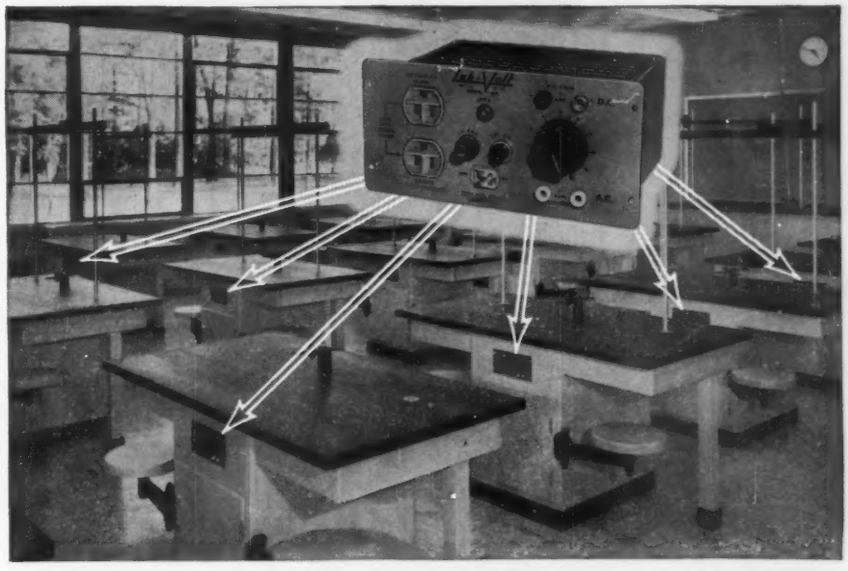

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New Science Films

The two reports given in this issue represent new projects in film communication. It is without question that in today's science curriculum every form of audio-visual aid has an important role. These currently produced films were planned to supplement and strengthen what is taught in science in the particular subject areas covered. Schools which need to offer an expanding and broad view to students in these areas will find considerable value in their use.

Horizons of Science

Reported by WESLEY W. WALTON

Director of Developmental Programs, Educational Testing Service, Princeton, New Jersey

CAREFULLY selected and effectively used, audio-visual aids can do much to vitalize the science curriculum and to enhance conditions for learning. Motion pictures in particular have the potential of bringing subject content to life and of accelerating a science program of studies toward its objectives. This is especially true when the films present relevant material not otherwise readily available or as dramatically presentable to the pupil.

It can be said—borrowing from the educational psychologist—that the "end products of learning" for which science courses are taught fall into five classifications: skills, knowledge, understanding, attitudes, and appreciations. Most films in the sciences are designed to function in the development of skills as in the use of laboratory equipment, knowledge as in the mastery of facts, and understanding as in the comprehension of concepts. Few indeed are the science films which are especially designed to function in the development of attitudes and appreciations. Such a group of films, *Horizons of Science,* recently has been completed and released by the Educational Testing Service of Princeton, New Jersey.

This series of ten, twenty-minute films in color and sound, *Horizons of Science,* is defined as a motivational program. The films are designed to stir imaginations and to stimulate thinking among pupils. They give pupils cause to be favorably disposed toward the sciences and mathematics, both as courses of study in school and as careers to plan for in the future. The approach to the pupil is through the scientist. A practicing scientist, outstanding in his field, is the communications link between each of ten scientific disciplines presented in the series and the youngsters who see the films. The seasoned scientist communicates to the embryonic scientist and the upcoming citizen toward whom the nation must look for future advances in science and the understanding of scientific efforts.

The primary objectives of *Horizons* then are twofold: (1) to cultivate appreciation by secondary school pupils of the works, satisfactions, and problems of scientists; and (2) to encourage on the part of the young people positive attitudes toward scientists as people and toward sciences as attractive areas for academic, technical, and professional pursuit, and also for knowledgeable lay observation.

The pattern for the series is for a scientist of national reputation in his field to bring to the screen the story of his work, the hallmarks of progress, the personal satisfactions, and the relevance of this work to the needs of our time. Ten major fields of science and research are treated. Each film brings an experience with the men, methods, and tools of science parallel to a field trip to the laboratory with the scientist as a guide. Seen as a program, the series ranges broadly over social, biological, physical, and earth sciences and places applied and especially basic research in perspective as the keystones of all science.

The synthesized "field trips" take students to and through the perception laboratories and illusional demonstrations of psychologist Hadley Cantril; the microbiology laboratory with cinemicroscopy techniques shown by entymologist Roman Vishniac; the plastic balloon systems of Otto Winzen with flights to 100,000 feet; the electronic research and development facilities of the laboratories of the International Business Machines, Bell Telephone, and the Massachusetts Institute of Technology; the test model Mississippi River basin of the Army Engineers; the study of change in a cultural "laboratory" with anthropologist Margaret Mead; geophysical and oceanographic observations from the research vessel *Vema;* the Palomar Observatory with its 200-inch reflector; the center for physiological research at the New York University College of Medicine with its multi-discipline research team; and the particle accelerators and nuclear reactors for basic re-

A radiation experiment using rats is begun to determine the effects of X rays on the capillaries. Dr. Evelyn Rosenberg, New York University College of Medicine, tells of basic research in the microcirculation of blood and the capillary bed in "The Flow of Life."

The exploration into the nature of matter and behavior of the neutron is told in "Neutrons and the Heart of Matter." Dr. Donald J. Hughes, nuclear physicist and authority on neutrons, with Assistant, checks the generator used to accelerate particles over 95 per cent the speed of light (approximately 186,000 miles/second in air).

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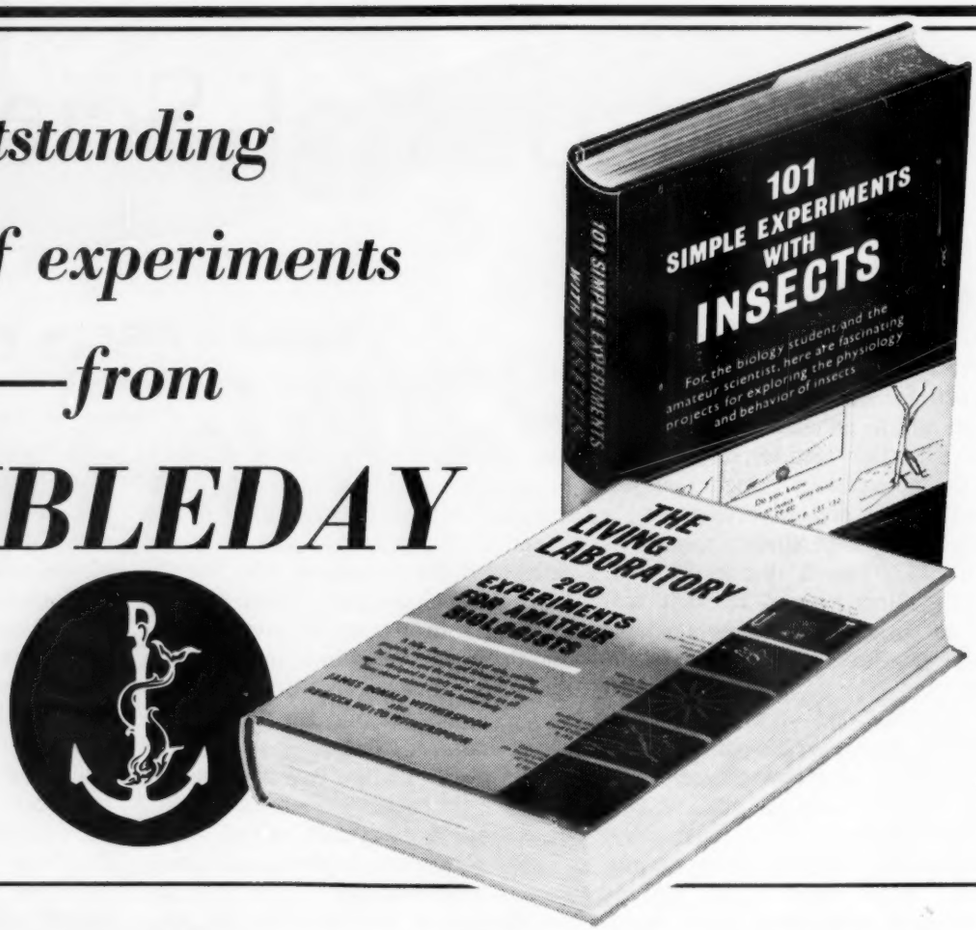

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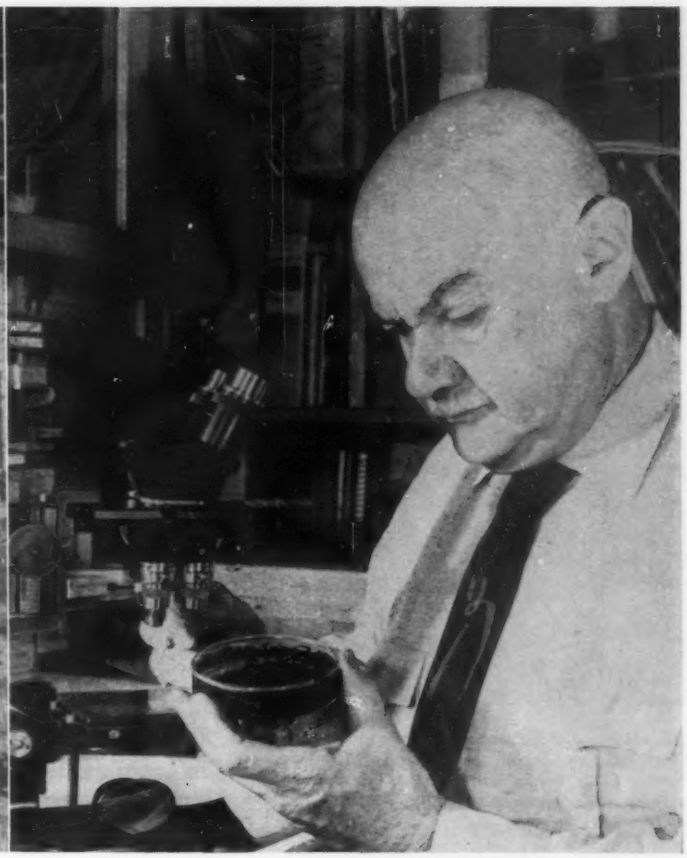
A core sample, representing nine million years of sedimentation, has been removed from a depth of more than three miles in the Caribbean. The Horizons of Science film, "Project Mohole," shows the work of a team of scientists who plan to drill a hole through the crust of the earth.



Entomologist and microbiologist, Dr. Roman Vishniac works alone in his small home laboratory in New York. He makes photographs and motion pictures of living things too small to be seen by the naked eye. "The Worlds of Dr. Vishniac" shows the life function of microscopic, one-celled animals through extraordinary cinemicroscopy.

search in atomic energy at the Brookhaven National Laboratory. These are awe-inspiring places, and the scientists who have taken the opportunity in *Horizons* to communicate with school pupils are inspired men and women.

Horizons of Science would seem to offer an unusually fine opportunity for the inspired teacher productively to supplement his program of instruction. The films purport to help teachers achieve an end among the most difficult to achieve in measurable amounts—to positively develop and/or change the attitudes of young people. The *Horizons'* approach to science films is commended to full and careful evaluations of usefulness in this challenging sphere of instruction.

The success with which the prime objectives of *Horizons* eventually will be met is of course neither known at this time nor to be easily derived. Early reports seem to indicate, however, that some degree of success already is being realized. Having had the benefit of the *Horizons* program as an augmentation of regular science courses of study, for example, students have been inspired to launch projects of independent related reading and study, for the construction of dynamic devices and principle demonstrators, and for the conduct of complex experiments.

Happily enough, a natural path exists from seeing the film to carrying out the followup. Where used with maximum effectiveness, each film is seen at least three times: once for pleasure, once for probing, once for "pay." The sheer beauty of the mathematics in a river, the awesomeness of spiral nebulae, the fascination of the heart-throbbing flow of life, the darkness of space—these kinds of striking phenomena portrayed on the *Horizons* screen leave but few unmoved. The films, seen at first, are to be enjoyed.

A second screening for probing brings fundamental observations. What kind of person is the scientist? What gratifications does he get out of his work? How does he go about his work? What does he learn? What are the remaining mysteries in his field? How do both success and failure mark his progress? Where does basic research fit into the pattern of man's progress? These student probes, helped along by insights communicated by the narrating scientist in each film and by class discussion, are the grist of the motivational mill.

Three generalizations seem appropriate for use as criteria to measure success in the probing phase. Briefly stated they are as follows: (1) The enthusiasm conveyed by a scientist about his field is contagious. (2) The intensity of interest in the scientific field at first exposure is roughly proportional to the degree to which the pupil can visualize that field. (3) In talking "straight" to the pupils (rather than "down" to them), the scientist lifts them to a level of sophistication still within their reach.

Dr. Margaret Mead, cultural anthropologist at the American Museum of Natural History, wears a feathered hand-carved war charm of the Manus culture in New Guinea. Charms are worn during battles as in the culture's competitive ceremonies. In "New Lives for Old," Dr. Mead tells of the striking changes experienced in a twenty-five year period by the people of the Admiralty Islands.

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Conventional outcomes of knowledge and understanding should result from a third screening. Judicious use of the Study and Discussion Guides would seem to assure that the subject matter content of the films is put into course of study context, absorbed and assimilated by the pupils. The Guides present technical discussion of the film content, detailed topical outlines for class discussion, simple experiments and demonstrations as well as other student activities, short-answer test questions, and bibliography for both student and teacher.

As may have been apparent from the above, the *Horizons*' series has secondary objectives of a more conventional nature. But here as well, the program is horizon-wide. Broader understanding of science and its place in our world today is equally important to the individual who is a serious student in science and to his counterpart who has regarded with trepidation science and mathematics courses or careers. In fact, a clear understanding of the world of science is vital for all Americans today. Individually and collectively dependent on scientific progress for continued security, strength, and vitality, the members of our democratic society need to know more and more of science in order to function effectively. The objectives of knowledge and understanding in the series are cast in this light.

It is of course true that there is a natural niche for each film in the *Horizons*' series in some science course. One may hope, however, that its typical use will be as a program breaking the bounds of science compartments so as to be assimilated by the widest possible audience.

The major problem to be encountered in making effective use of these films, it seems to us, is to find the place in the school program where the films can serve their best purposes. The breadth of subject treatment which characterizes the series is at once a blessing and a burden. Where are the blocks of time to present a film program which ranges from psychology to oceanography, from astronomy to microscopy? If one faces this challenge successfully, the benefits are bound to be manifold.

NOTE: See review under Audio-Visuals, The Science Teacher, October 1960. p. 58.

Planet Earth

Reported by HUGH ODISHAW

Executive Director, U. S. National Committee for the IGY and the Space Science Board, National Academy of Sciences-National Research Council, Washington, D. C.

THE "Planet Earth" film series of the National Academy of Sciences presents an up-to-date delineation of man's physical environment. The films embrace thirteen areas of the geophysical sciences and are concerned with the solid earth, surface and lower-atmosphere phenomena, the upper atmosphere, and space. Although each film has its own specific subject and title and can thus be used separately, the series as a whole presents an overall review of our planet as seen in the light of present-day geophysical knowledge.

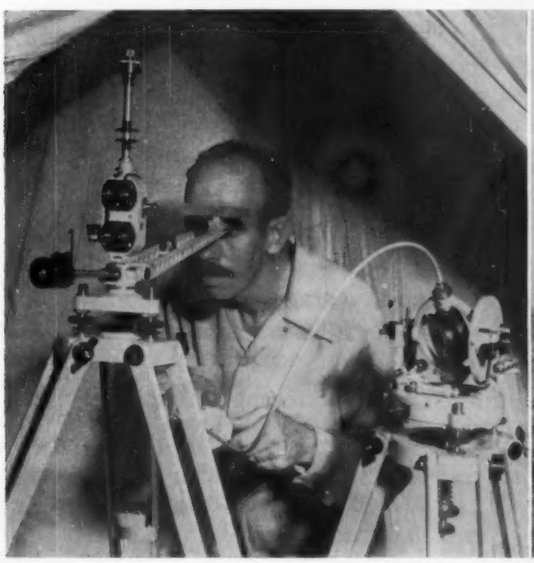
The series represents the only film activity specifically undertaken by the Academy. It originated in the interest of students, teachers, and the general public in the International Geophysical Year. Long before the onset of this unprecedented eighteen-month period of world-wide experiments and observations, the IGY had captured the imagination of young and old alike. This interest heightened as programs were undertaken and realized, and one of its consequences was a deluge of letters and inquiries from young students and their teachers.

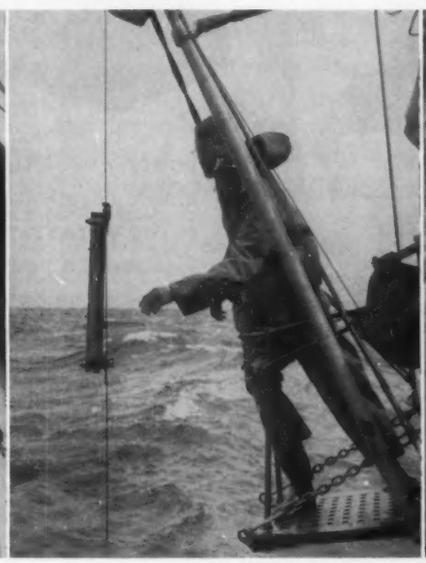
In response to these and related expressions of interest, several steps were taken by the Academy of an educational nature, of which the present film program is one. To assist in their development, an Advisory Committee on Education (IGY) was established by the President of the Academy.[1] In addition a Working Group, consisting of representatives from such organizations as the National Education Association, National Science Teachers Association, U.S. Office of Education, and the National Science Foundation, was set up to assist particularly with the film program.

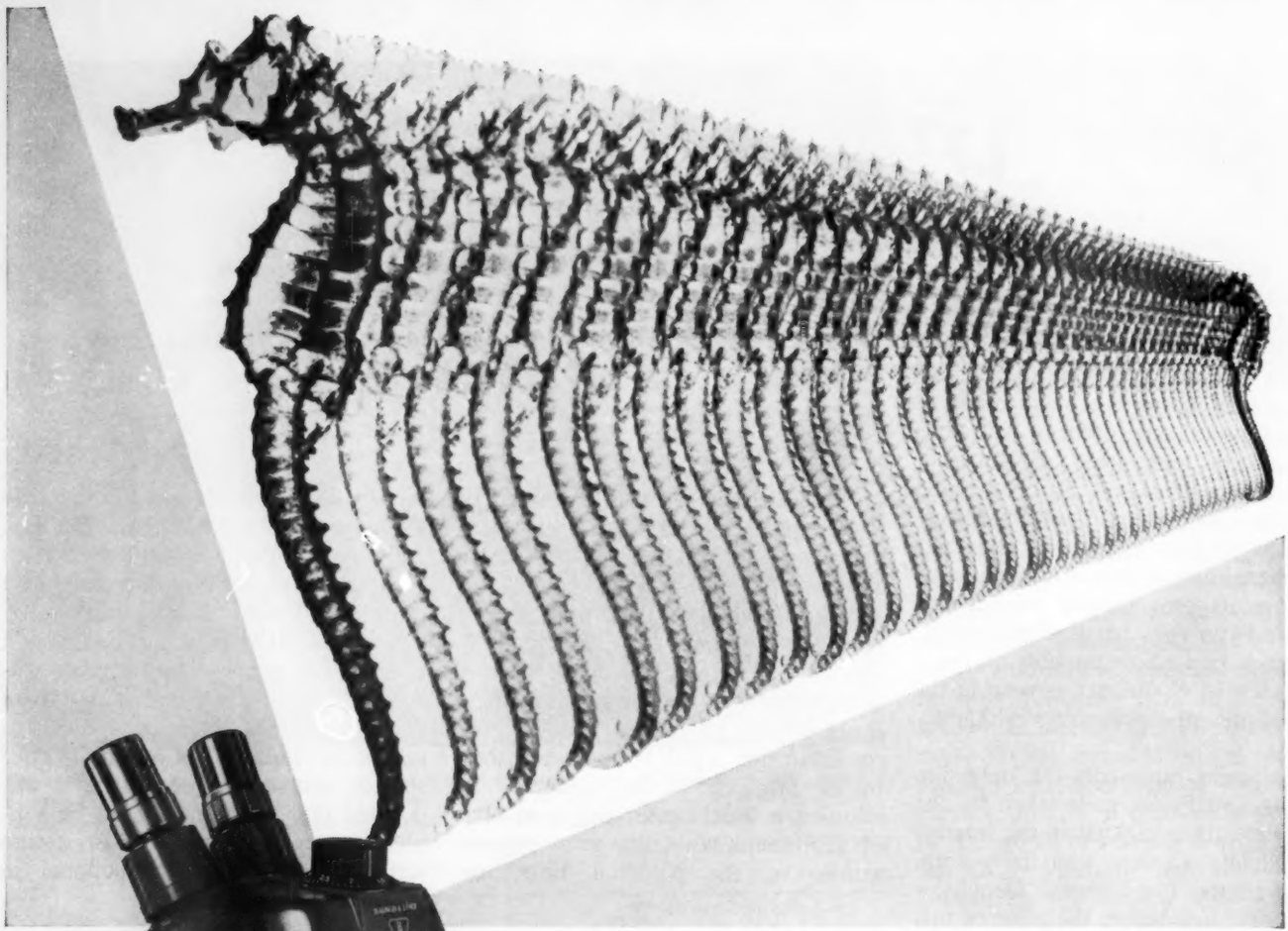
The general approach to be taken in treating the geophysical sciences was determined by the members of these two committees. Because precollege school curricula do not ordinarily offer specific courses in geophysics, it was decided that the films should be supplementary and enriching in nature rather than entirely instructional in

[1] Wallace W. Atwood, Jr., Director, Office of International Relations, National Academy of Sciences; James S. Coles, President, Bowdoin College; Carey Croneis, Provost, Rice Institute; Laurence M. Gould, President, Carleton College; J. Wallace Joyce, Head, Office for Special International Programs, National Science Foundation; Joseph Kaplan, National Academy of Sciences, and Professor of Physics, University of California at Los Angeles; John R. Mayor, Director of Education, American Association for the Advancement of Science; Hugh Odishaw, Executive Director, U.S. National Committee for the IGY, National Academy of Sciences; Alan H. Shapley, Vice-Chairman, U.S. National Committee for the IGY, National Academy of Sciences; Randall M. Whaley, Executive Secretary, Advisory Board on Education, National Academy of Sciences.

The geophysical sciences lead scientists to nature where theories must be tested against facts and where new data are acquired. Aboard the research vessel Crawford, a scientist lowers a Nansen bottle to measure deep-ocean temperatures and retrieve water samples for analysis. The earth's magnetic field is measured at field stations around the world. Gravity measurements are made quickly and simply at thousands of scattered points to get a picture of the earth's over-all gravitational field. In the "Planet Earth" films, laboratory scenes and animation of abstract ideas are supplemented by important field experiments, which also show scientists at work and how they conduct their investigations.







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City..... *Zone*..... *State*.....

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To understand the nature of Earth requires exploration and research in remote regions. Cores of ice are studied in Antarctica. Ice cores, here from Greenland, are drilled to thousands of feet in both polar regions. The samples are flown to home laboratories for analysis as scientists seek to understand their composition and to find clues to past and present trends in climate. To acquire significant footage for the "Planet Earth" series, film crews were sent to scores of field stations around the world.

character. It was hoped that the films would thus complement curricula in the earth sciences, in physics, and in geography.

It was felt that the films should not only stimulate interest and arouse curiosity in geophysics, but that they should also convey a substantial body of scientific knowledge. In this way the viewer would not only be guided toward a more realistic interest in geophysics, but would have immediately before him appreciable scientific information and data to sustain that interest. This approach also permits the teacher to prepare lectures on the major topics of each film, using sections of a film as introductions to each of the lectures.

Although the inspiration for the program came from the IGY, the films are in no sense IGY films. The content in any given field, while utilizing the striking results of the IGY, ranges from early to present-day ideas and experiments, with projections into the future. Each film generally begins with a minute or so of significant scenes and commentary, stating the subject and raising provocative questions. After the title, ancient concepts are alluded to briefly, followed by discussion of major ideas and discoveries of the preceding two or three centuries. This chronological section not only suggests the growth and development of science in each discipline, but turns out to be an interesting and simple way to explain many fundamental concepts which are simpler in their historic presentation and which serve to provide a base for later developments. The remainder and the bulk of each film take up modern discoveries and activities. Thus the films attempt to give a rounded picture of man's quest for knowledge in each field, outlining the principal discoveries and ideas and raising questions that still challenge science.

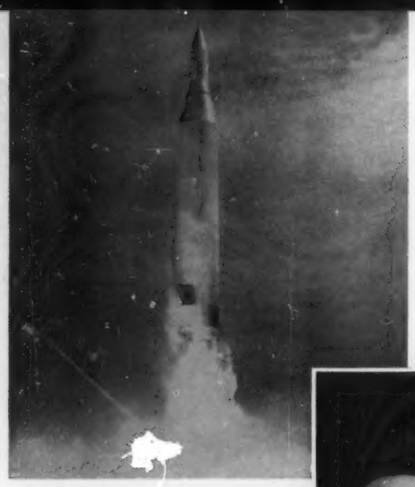
Of the thirteen films, three are devoted to the solid earth: *The Hidden Earth* (seismology), *The Shape of the Earth* (geodesy), and *The Force of Gravity*. Three others explore interface environment between the solid earth and the high atmosphere: *The Inconstant Air* (weather and climate), *Secrets of the Ice* (glaciology), and *Challenge of the Oceans* (oceanography). Seven films are concerned with the upper atmosphere and space: *Our Nearest Star* (the sun and solar activity), *The Flaming Sky* (aurora), *Magnetic Force* (the earth's magnetic field), *Radio Waves* (including the ionosphere and radio astronomy), *Cosmic Rays, Research by Rocket,* and *Science in Space* (satellite and space-probe research).

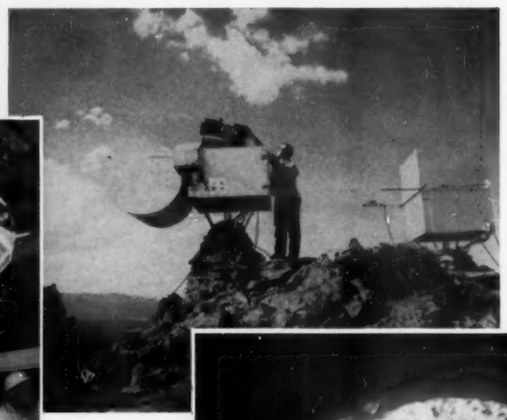
In the production of the films, specialists in each of the thirteen fields were called upon for guidance from all parts of the country and even abroad. Thus the scientific soundness of the films was insured. Because many of the ideas in geophysics are abstract, animation is used as needed. Live footage ranges from laboratory experiments to field activities. Film crews were sent to many parts of the world for this footage. An important consequence is that the films show scientists at work, and how they work in nature, from the tropics to the poles. The legitimate adventure of man's coping with his environment and of scientists' seeking knowledge from nature is often reflected in the field work. Moreover, the planetary nature of geophysical problems is revealed by the scenes from other countries and from remote regions like the Antarctic.

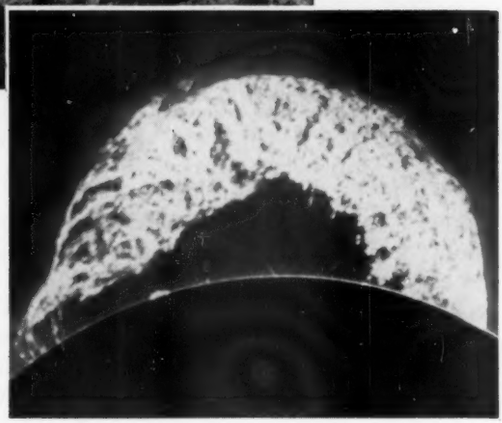
Pre-release testing has been extensive. Several hundred of the nation's leading geophysicists reviewed the films as they were being made as well as upon completion. More than a thousand high school science teachers have screened and discussed the series during this last summer at many of the Summer Science Institutes supported by the National Science Foundation. Several hundred young students, as well as at least an equal number of adults, have also been exposed to them. The reactions of these varied groups have been remarkably favorable and uniformly so, suggesting that the series has attained the objectives.

Each of the films is approximately twenty-seven minutes in length. Produced in sixteen-mm color, all are available in color or in black and white, and all have appropriate sound-track narrative with some music. The distributor, to whom inquiries on purchase of the films may be addressed, is the McGraw-Hill Book Company, Text-

Film Department, 330 West 42nd Street, New York 36, New York. General inquiries relating to the program may be addressed to the Executive Director, U.S. National Committee for the IGY, National Academy of Sciences, 2101 Constitution Avenue, Washington 25, D. C.







Studies of the upper atmosphere and space are the subjects of seven films in the "Planet Earth" series. Here (upper left) the launching of Explorer VII with the payload (detailed insert) is shown. Atop Fritz Peak, Colorado, scientists use a scanning photometer to explore the airglow. Solar prominences, photographed at the High Altitude Observatory, are an important feature of the sun whose activity influences particles, fields, and radiations in space and in the earth's upper atmosphere.

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USES OF SURPLUS PROPERTY MATERIALS

By ALAN MANDELL

Science Supervisor, Norfolk County Public Schools, Norfolk, Virginia

THE procurement of surplus equipment and materials for science programs is possible through the donation program of the Surplus Property Utilization Division of the U. S. Department of Health, Education, and Welfare. A general description of the program, history, and administration is presented, followed by some suggested applications in science education of inexpensive materials obtainable through the program.

History and Organization

Following World War I, the Sixty-sixth Congress recognized the value of making surplus property available to educational institutions in the United States. Accordingly, Congress passed Public Law 91 in November 1919. Thus from this historic beginning to the present time, Federal agencies and independent departments have had authority to make any obsolete or surplus property, no longer needed by the Federal government, available for donation to education programs. The laws giving this authority are based upon the philosophy that educational institutions could use such equipment to train the youth of our country toward productive lives in our technological society, and that the public benefit derived thereby would far surpass any monetary return recovered from the sale of such material.

The Congress has charged the Secretary of Health, Education, and Welfare with the responsibility for administering the donation of surplus property to eligible health and educational groups. By delegation from the Federal Civil Defense Administrator, the department also performs the function of allocating surplus property to state agencies for donation to eligible civil defense programs.

The Secretary of Health, Education, and Welfare has authorized Regional Representatives to make determinations that specific property items are useful and necessary for health and educational purposes in the various states and to allocate the property on the basis of needs and utilization. The Regional Representative has over-all responsibility for the locating and screening of all Federal surplus property generating at installations within his region. Congress has further provided for the participation of authorized state agencies for surplus property in carrying out these responsibilities. These state representatives will provide science teachers with guidance in the program, for they are directly responsible for all distribution within their state.

There are nine Regional Representatives (see Table I) and fifty-three state and territorial agencies. The state agency personnel perform the actual screening and selection of surplus materials within their state or territory and are the persons from which information may be requested on materials currently available and/or required by science teachers. In many states, school personnel are invited to participate in direct screening and selection of materials at Federal activities' "supermarket" days. Science teachers can reach the director of any state agency through the Regional Representative's office (see Table I) or through the state government and request authorization as designated representatives of eligible institutions.

The costs for this equipment and material to the local school or school system are negligible. The Federal government donates the material to state agencies and the only charge to schools within the state accepting the material represents the state's cost in transporting, storing, and administering the program. The average cost to schools nationally is four per cent of the original cost to the Federal government. Thus items which cost the government $100 originally would cost the schools, on the average, only $4. More specifically, electronic meters (voltmeters, ammeters, etc.) which cost $15 at original purchase price are available to schools at sixty cents apiece or less.

Much of the material in this program is new and unused and is often dis-

tributed in the original unopened container; other material has had some use by the services but continues to be durable and suited for longer use by the schools. Some materials will need conversion or repair; others will be useful only as sources of spare parts—"cannibalization" or combining two to make one. The program is in no way a "junk" program—most of the material has high intrinsic value and utilization.

Surplus Materials in Science Education

By its nature, science education in the precollege years depends upon a variety and plentitude of equipment and materials. Science becomes more meaningful to students when they can learn by observing, by experimenting, by testing, and by measuring. Because of the diversity of subjects that are studied in a complete science program from grades one through twelve, a wide variety of materials is required.

In general, equipment and materials, when obtained commercially, are expensive. With classes of thirty to forty students, sufficient amounts of these materials to permit all students a chance to experiment require considerable money.

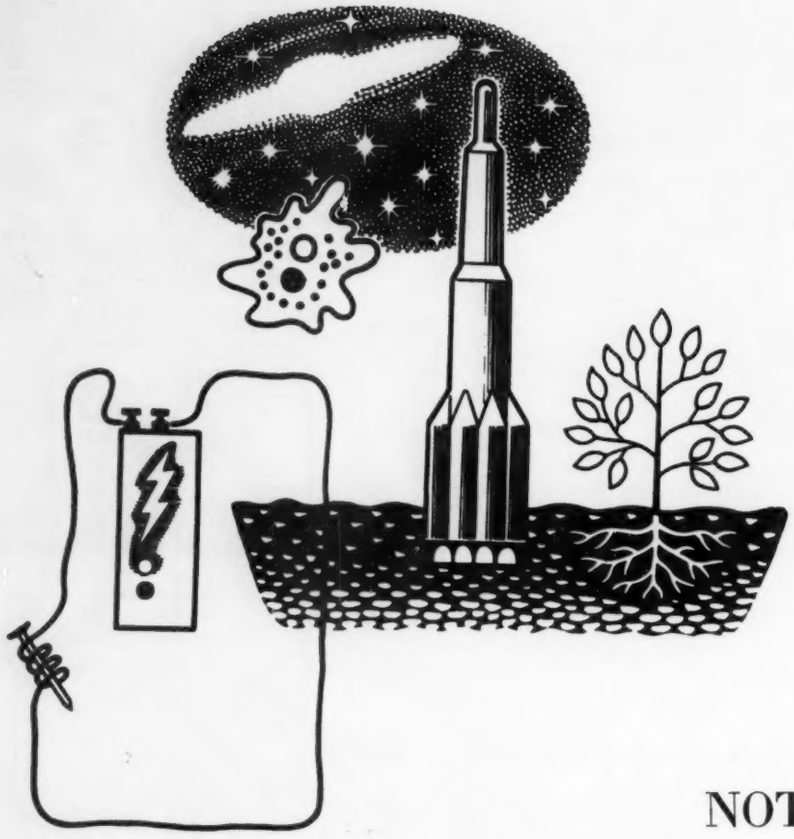
Reducing the cost of the items needed is one way in which surplus materials contributes to advance the science program in public schools. Perhaps a less obvious, but equally valid, contribution of surplus materials lies in the fact that students can learn to adapt materials to purposes other than originally designed to perform experiments. Converting the temperature gauge mechanism of an Army truck to a thermometric device for comparing the temperatures of different flames can be a more meaningful experience for a high school student than merely using a fancy commercial device. Many examples are found where devices intended for one use can and have been converted to a learning device.

Another contribution in the use of surplus materials combines the two ideas above. Because of their relative inexpensiveness and variety, surplus materials can be used for "finding out how it works." Electronic meters are expensive devices when purchased commercially, but surplus meters are inexpensive enough to justify allowing students to take one apart, examine the working relationship of the parts, and attempt to reassemble them for the purpose of achieving better understanding of meter principles.

Electronics materials (l. to r.): Test rig with galvanometer and milliammeter; tube tester; color-coded wire; headphones; assorted resistors, condensers, capacitors, potentiometers, transformers, knobs, vacuum tubes; field-strength meter; assorted voltmeters and ammeters; radiac Geiger counter; radiosonde transmitter (on breadboard layout).

Surplus materials make another important contribution to science education in the area of project activity. Properly utilized project activity can permit a wide variety of student skills, interests, and abilities to flourish. Be-

Weather and photography equipment (l. to r.): Thermometers (Fahrenheit and Centigrade); scales; field-weather station with anenometer and wind-direction indicator; psychrometer; film; paper; photochemicals; lenses; filters; reflectors; lens paper. (Some of the film cans in background contain surplus training prints applicable to secondary school programs.)



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cause of the diversity of equipment and materials available through surplus, these individual differences can be met more readily. One student may use the magnets of the radar magnetron to determine magnetic lines of force with iron filings; another student may use the same magnets to construct a beta-ray spectrometer.

Description of Materials

The science teacher who is not cognizant of this program may have difficulty in envisioning the amount and variety of equipment and materials available. If he can think of the diversity of equipment required to maintain and equip a modern Army, Navy, and Air Force and their related research and development programs, he will have some conception of the amount, for most of these items will appear in the surplus program at one time or another in quantities from one to several thousand.

Table II lists some of the subject areas of science and examples of commonly available surplus materials being used in these subject areas. This table is by no means complete, but should provide examples of the applicability of surplus items in science education. Many of the items listed will not be immediately available in State Surplus Property Agency warehouses. Specific requests from the educational institutions, however, will assist the state agencies in obtaining the desired equipment when it becomes available.

Summary

The donation program of the Surplus Property Utilization Division of the U. S. Department of Health, Education, and Welfare working through the regional and state agencies can do much to upgrade the teaching of science in our public schools. By making available a variety and quantity of needed equipment and materials, at practically no cost to the schools, this program is making an important contribution to the technical and scientific literacy of our youth. In the final analysis, this contribution may be more important than any other phase of our national defense planning.

Close cooperation and coordination between science teachers and state screening agencies can insure a continuous flow of these necessary materials from a surplus condition in the Department of Defense to a useful and productive state in the science departments of our schools.

Miscellaneous (l. to r.): Prisms and lenses; batteries; meters; bulbs; power supplies; rectifiers; heating element; watt-hour meter; hand tools.

TABLE I
Regional Directory
Division of Surplus Property Utilization

U.S. Department of Health, Education, and Welfare

REGION 1

Maine, New Hampshire, Vermont, Connecticut, Massachusetts, and Rhode Island

Edward G. Bradley
Regional Representative
Surplus Property Utilization Division
U. S. Department of Health, Education, and Welfare
120 Boylston Street
Boston 16, Massachusetts
Phone: Hubbard 2-6550

REGION 2

Delaware, New York, New Jersey, and Pennsylvania

Stephen L. Simonian
Regional Representative
Surplus Property Utilization Divison
U. S. Department of Health, Education, and Welfare
Room 1200, 42 Broadway
New York 4, New York
Phone: Whitehall 3-2424, Ext. 52

REGION 3

District of Columbia, Kentucky, Maryland, North Carolina, Puerto Rico, Virginia, Virgin Islands, and West Virginia

Dan A. Dollarhide
Regional Representative
Surplus Property Utilization Division
U. S. Department of Health, Education, and Welfare
700 East Jefferson Street
Charlottesville, Virginia
Phone: 3-5181

REGION 4

Alabama, Florida, Georgia, Mississippi, South Carolina, and Tennessee

L. Fred Carson
Regional Representative
Surplus Property Utilization Division
U. S. Department of Health, Education, and Welfare
Room 164, 50 Seventh Street, N.E.
Atlanta 23, Georgia
Phone: Trinity 6-3311, Ext. 5024

REGION 5

Illinois, Indiana, Michigan, Ohio, and Wisconsin

W. D. Musser
Regional Representative
Surplus Property Utilization Division
U. S. Department of Health, Education, and Welfare
Room 712, 433 West Van Buren Street
Chicago 7, Illinois
Phone: Wabash 2-8550, Ext. 61 or 62

REGION 6

Iowa, Missouri, North Dakota, South Dakota, Kansas, Minnesota, and Nebraska

Mel R. Summers
Regional Representative
Surplus Property Utilization Division
U. S. Department of Health, Education, and Welfare
Room 2305, 911 Walnut Street
Kansas City 6, Missouri
Phone: Baltimore 1-7000, Ext. 8351

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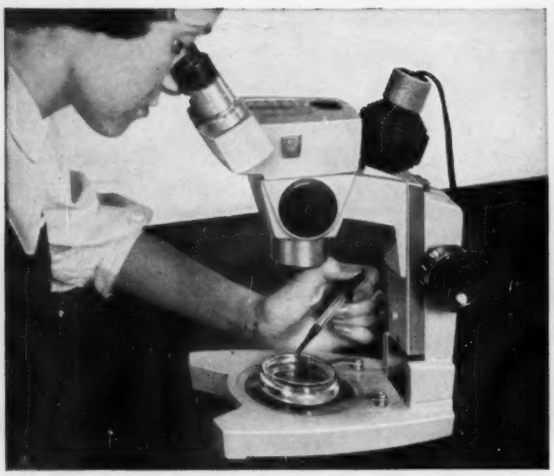
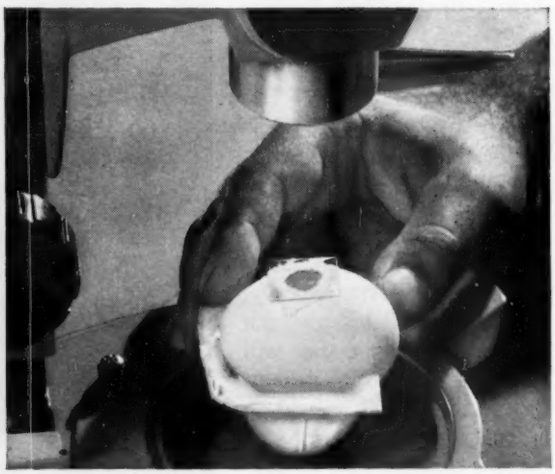
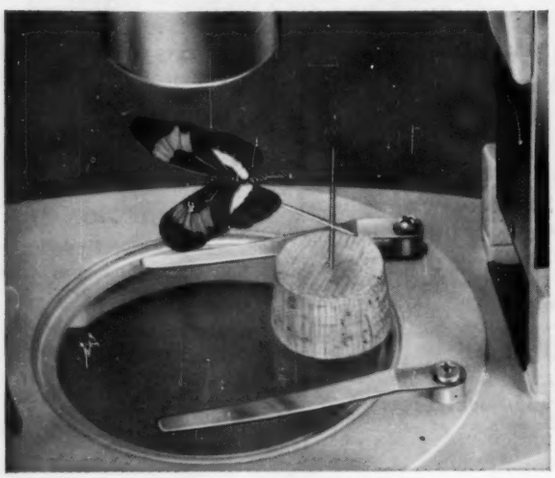


Hunt and select individual protozoan with eye dropper



Study living chick embryo during development



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REGION 7

Arkansas, Louisiana, New Mexico, Oklahoma, and Texas

Sam G. Wynn
Regional Representative
Surplus Property Utilization Division
U. S. Department of Health, Education, and Welfare
1114 Commerce Street
Dallas 2, Texas
Phone: Riverside 8-5611, Ext. 385

REGION 8

Colorado, Idaho, Montana, Utah, and Wyoming

Clayton S. Brown
Regional Representative
Surplus Property Utilization Division
U. S. Department of Health, Education, and Welfare
Room 551, 621 17th Street
Denver 2, Colorado
Phone: Keystone 4-4151, Ext. 237

REGION 9

Arizona, California, Nevada, Oregon, Washington, Alaska, and Hawaii

Paul R. Flynn
Acting Regional Representative
Surplus Property Utilization Division
U. S. Department of Health, Education, and Welfare
Civic Center
447 Federal Office Building
San Francisco 2, California
Phone: Klondike 2-2350, Ext. 6653, 6652

TABLE II

Subject Matter Area—Examples of Applicable Surplus Materials

Astronomy—Telescopes (Ordnance and Fire control equipment, Bore-sighting devices, Range finders, Gun sights, other telescopes), Binoculars, Sextants, Compasses (magnetic and gyroscopic), Pelorus, Survey transits, Plumb bobs, Drawing tables, Tools, Clocks, Stop watches, Cameras, Films, Photochemicals, Photo equipment, Lenses, Prisms, Mirrors, Books, Navigational texts, Star almanacs, Star finders, etc.

Aviation—Whole plane (prop-type or jet) and any or all of its associated parts.

Biology—Hospital supplies (Dissecting kits, Operating room lights, Dental drills, Eye charts, ECG equipment, Diathermy machines, X-ray units and film, Refrigerators, Autoclaves—large and small, Incubation ovens, Glassware, First Aid kits and supplies, Centrifuges, Chemicals), Magnifying lenses, Books (Medical texts, First Aid manuals, etc.), Life rafts, Small boats, Shallow-water diving outfits, Pumps and Motors, Knapsacks and other field-trip containers, Tents, Mosquito netting, Bottles and Containers for specimens, Large Cooking utensils and Baking pans for germination, potting, etc.

Chemistry—Chemicals, Glassware, Bottles, Silica gel (dehydrant), Filter paper, Thermometers, Pressure gauges, Combustion ovens, Clocks, Stop watches, Rubber, Glass and Plastic tubing, Fire extinguishers, Radiac equipment, pH meters, Gas analyzers, Soil-test kits, Water purification and distillation equipment, Pumps and Motors, Pyrotechnics, Magifying lenses.

Geology—Geodetic equipment, Knapsacks, Magnets, Magnifying lenses, Maps, Transits, Plumb bobs, Short-range radio transceivers, Photography equipment, Tools.

Mathematics—Sextants, Transits, Calipers, Micrometers, Globes, Graph paper, Audio-visual equipment, Books.

Photography—Cameras (still and motion), Projectors, Enlargers, Film paper and Photochemicals, Darkroom equipment, Lenses, Mirrors, Timers, Filters, Flash attachments, Flood lights, Special-purpose film (X-ray, ultraviolet, infrared), Aviation cameras (provide large lenses, shutters, iris diaphragm, etc., for demonstration purposes).

Physics

1. **Measurement**—Scales, Balances, Weights, Rulers, Calipers, Micrometers, Thermometers, Gauges, Levels, Tape measures, Specific gravity specimens (scrap metal, porcelain, etc.), Clocks, Stop watches, Meters (all types), Timers, Graph paper.
2. **Mechanics**—Spring scales, Pendulum plumb bobs, Ceramic rollers, Ball bearings, Gyroscopes, Piano stools, Rubber, Plastic and Glass tubing, Compressors, Pumps and Motors, Fans, Balloons, Rams, Hydraulic pumps and gauges, Valves, Thermometers, Fluid couplings, Carburetors, Paint sprayers, Atomizers, Altimeters, Barometers, Plumbing fittings and tools.
3. **Machines**—Complete engines (automotive, aviation, gasoline, diesel, jet), Associated engine parts, Tools and Test devices, Pulleys, Chain falls, Wire, Rope, Thread.
4. **Heat, Sound, and Light**—Parabolic reflectors, Lights, Range finders, Lenses, Prisms, Mirrors, Filters, Cameras and parts, Tank and Submarine periscopes, Thermometers, Pyrometers, Ovens, Lamp chimneys, Buzzers, Vacuum pumps, Meters (all kinds), Lucite and Plexiglass, Projectors, Optical instruments, Lens paper, Piezo-electric crystals, Recording devices, Lens grinding compound, Amplifiers, Speakers, Sonic transducers, Sonar equipment, Heligraph equipment, Tools.
5. **Electricity**—Meters (all kinds and ranges), Wire, Switches, Magnets, Electromagnets, Sockets, Fuses and Fuse blocks, Receptacles, Plugs, Resistors (all kinds and ranges), Wheatstone bridges, Motors, Generators, Variacs, Power supplies, Batteries (wet and dry cell), Metal strips, Bars and Rods, Watt-hour meters for demonstration, Coils, Transformers, Potentiometers, Test meters and devices, Special testing rigs, Telephones, Panel and switchboards, PA systems, Intercom systems, Telegraph keys, Telegraph sounders, Amplifiers, Transducers.
6. **Electronics**—Resistors, Capacitors, Electron tubes, Transistors, Crystals, Thermistors, Klystrom tubes (all types and sizes), Radar transmitters and receivers, Radio transmitters and receivers, Sonar, Loran, Telemetering equipment, spares and parts for above equipment. Test equipment, Meters (all kinds), Metal of all types, Electronics hardware, Tools, Books, Kits, X ray, Sound recording, Degaussing equipment and parts.
7. **Modern Physics**—Radar, Loran, Sonar, Infrared communication equipment, Telemetering parts and devices, Radac equipment, Geiger counters, Scalers,

Elementary science kit which includes: String; pins; lenses and prisms; thermometers; bulbs; wire; switches; fuses; telegraph keys and sounders; headphones; test tubes; balloons; plumb bob; rollers; pitchers; tray.

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The only part subject to deterioration is the charge-carrying belt, which is readily replaceable.

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It is a distinguishing difference of the GENATRON that electrical charges, conveyed by a non-metallic material, are established *directly upon the discharge terminal.* The attainable voltage accordingly depends only upon the geometry of that terminal and the dielectric strength of the medium by which it is surrounded.

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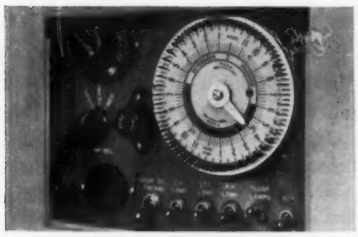

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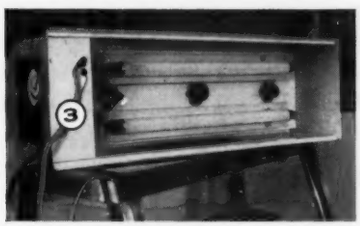

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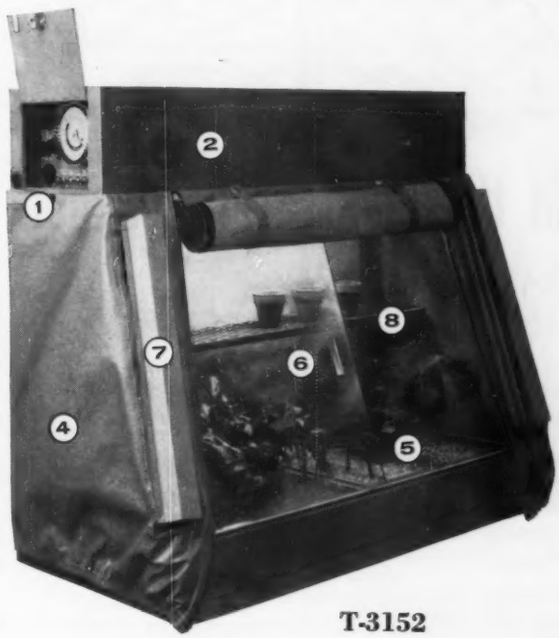

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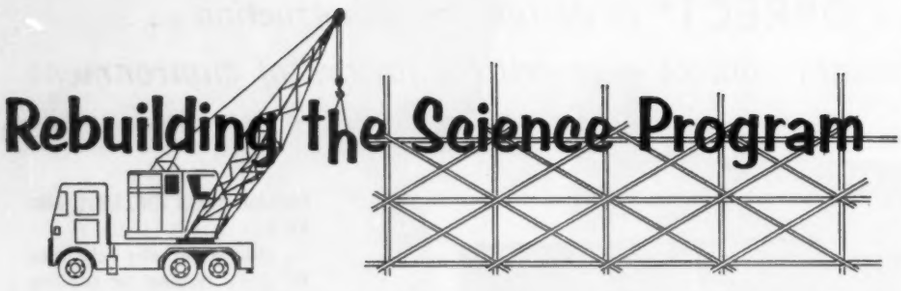

Inquiry Training in the Elementary School

By J. RICHARD SUCHMAN

Director, Studies in Inquiry Training, University of Illinois, Urbana, Illinois

SKILLS of scientific inquiry are being taught to elementary school children at the University of Illinois through the use of motion pictures and verbal "experimentation." For the past three years, a research project known as the Illinois Studies in Inquiry Training[1] has been experimenting with the teaching of strategies and tactics of scientific inquiry to children who learn to apply them in question-and-answer investigations. Short films of physics demonstrations pose problems of cause and effect. The children learn to attack these problems with questions by which they gather data and perform imaginary experiments. The teacher provides the answers to the questions.

A portion of a typical session would go something like this: (The children have been shown a film of the "Ball and Ring" demonstration.)[2]

PUPIL: Were the ball and ring at room temperature to begin with?
TEACHER: Yes.
PUPIL: And the ball would go through the ring at first?
TEACHER: Yes.
PUPIL: After the ball was held over the fire it did *not* go through the ring, right?
TEACHER: Yes.
PUPIL: If the ring had been heated instead of the ball, would the results have been the same?
TEACHER: No.
PUPIL: If both had been heated would the ball have gone through then?
TEACHER: That all depends.
PUPIL: If they had both been heated to the same temperature would the ball have gone through?
TEACHER: Yes.
PUPIL: Would the ball be the same size after it was heated as it was before?
TEACHER: No.
PUPIL: Could the same experiment have been done if the ball and ring were made out of some other metal?
TEACHER: Yes.

Such questioning continues for about thirty minutes as the children gather data, identify variables and determine their relevancy to the problem, and formulate hypotheses of cause and effect which they test experimentally. No data are given that the children do not obtain through observation or from the teacher's "yes" or "no" answers to their highly structured questions.

To these children and others who are inquiring into the causes of physical phenomena, science is the discovery of new relationships. Children sometimes discover by accident; and sometimes "discovery" is carefully contrived by a skillful teacher. Whichever way it occurs, children are typically thrilled by the sudden new insights, and the learning that results has deep roots. But if we are going to teach the child how to discover meaningful patterns independently and consistently in a highly complex environment, we must teach him how to probe aggressively, systematically, and objectively, and how to reason productively with the obtained data. In other words, we must teach him the skills of inquiry.

Objectives

Inquiry training is designed to supplement the ordinary science classroom activities. It gives the child a plan of operation that will help him to discover causal factors of physical change through his own initiative and control, and not to depend on the explanations and interpretations of teachers or other knowledgeable adults. He learns to formulate hypotheses, to test them through a verbal form of controlled experimentation, and to interpret the results. In a nutshell, the program is aimed at making pupils more *independent, systematic, empirical,* and *inductive* in their approach to problems of science.

The Strategy of Inquiry

The children are given a general three-stage plan to guide them in their investigations and help them develop a logical, systematic approach. Each stage has its own goal and a set of tactics helpful in attaining it.

Stage I. Episode Analysis.

Goal: The identification, verification, and measurement of the parameters of the problem.

In order to perform the operations of this stage, the child must learn to use a set of categories to describe and analyze each episode. Taken together, these categories form a logical system in which each element has an established relationship to the others. The episode-analysis categories are as follows:

1. *Objects:* Objects are the easiest elements for the children to recognize. Familiar objects that are clearly visible pose no problems. The chief difficulty is identifying *all* the objects, whether or not they are visible, familiar, or seemingly unimportant. Included in this category are *systems,* two or more objects combined to form a functional unit. As such they have certain properties that the objects do not possess separately. Water is an object; a beaker is an object. A beaker of water may be regarded as a system.
2. *Properties:* Properties relate to both objects and systems. A property of an object is its predisposition to behave a certain way under a given set of conditions. Properties may be identified through experimentation. By placing an object under varying conditions and observing the resulting changes, a person can determine as many of its properties as he may desire. The identification of objects by their properties is generally more useful than identification by name.

[1] This project is supported by a grant from the U.S. Office of Education, Department of Health, Education, and Welfare and by The Research Board of the University of Illinois.

[2] A brass ball just fits through a brass ring. The ball is then heated and placed on the opening of the ring which is held in a horizontal position. It does not slip through at once but is held in place by the ring. After some time has passed the ball drops through.

3. *Conditions:* Conditions pertain to the state of objects or systems. While the identity of an object remains constant, its conditions may change. Conditions are identified by observation or measurement.
4. *Events:* Events are defined as changes in the conditions of objects or systems. If an object moves, evaporates, expands, or merely gets hotter, an event has taken place. Events are the consequences of changing the conditions of objects or systems. The type or amount of change that is necessary to produce a given event is a function of the properties of the objects and systems involved.

Using a question-asking strategy to obtain the kinds of information defined by this system of descriptive categories, the child can collect and organize data which provide grist for the mill of inductive investigations.

Episode analysis involves a number of tactical operations. Careful observation must be supplemented by instrumentation and measurement. Many parameters or condition changes are not directly observable, yet may be critical factors in the causation of an event. If the child confines his attention to those variables which are striking or obvious, he is bound to overlook many highly significant dimensions. A thorough and orderly assessment of the objects, conditions, and events of an episode increases the probability of gathering all of the significant data.

One problem is that people tend to perceive new events and situations as total patterns (Gestalts) unless they have a specific set to analyze and a system of categories on which to base an analysis. Total perceptions may be superficial and misleading, causing children to make false analogies to similar total patterns. It is typical, for example, for children to conclude that a bimetallic strip is melting when it is held in a horizontal position over a flame so that it bends downward. The total pattern of this episode is identical to others in which a heated object melts. Yet a careful analysis would reveal the fact that the melting point of the metals is never even approached when the bending occurs.

Stage II. Determination of Relevance.

Goal: The identification of the conditions that are necessary and sufficient to produce the events of the episode.

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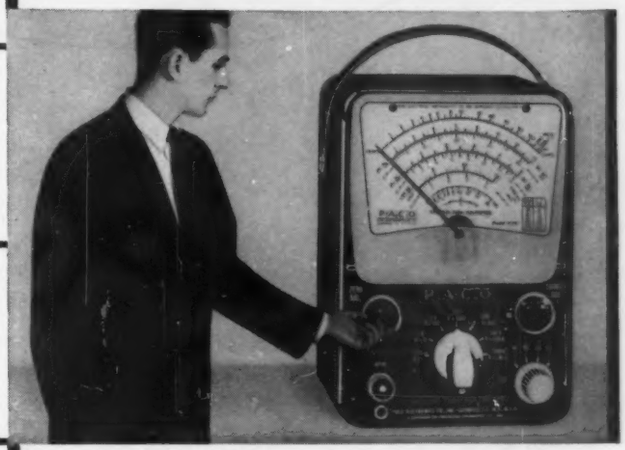

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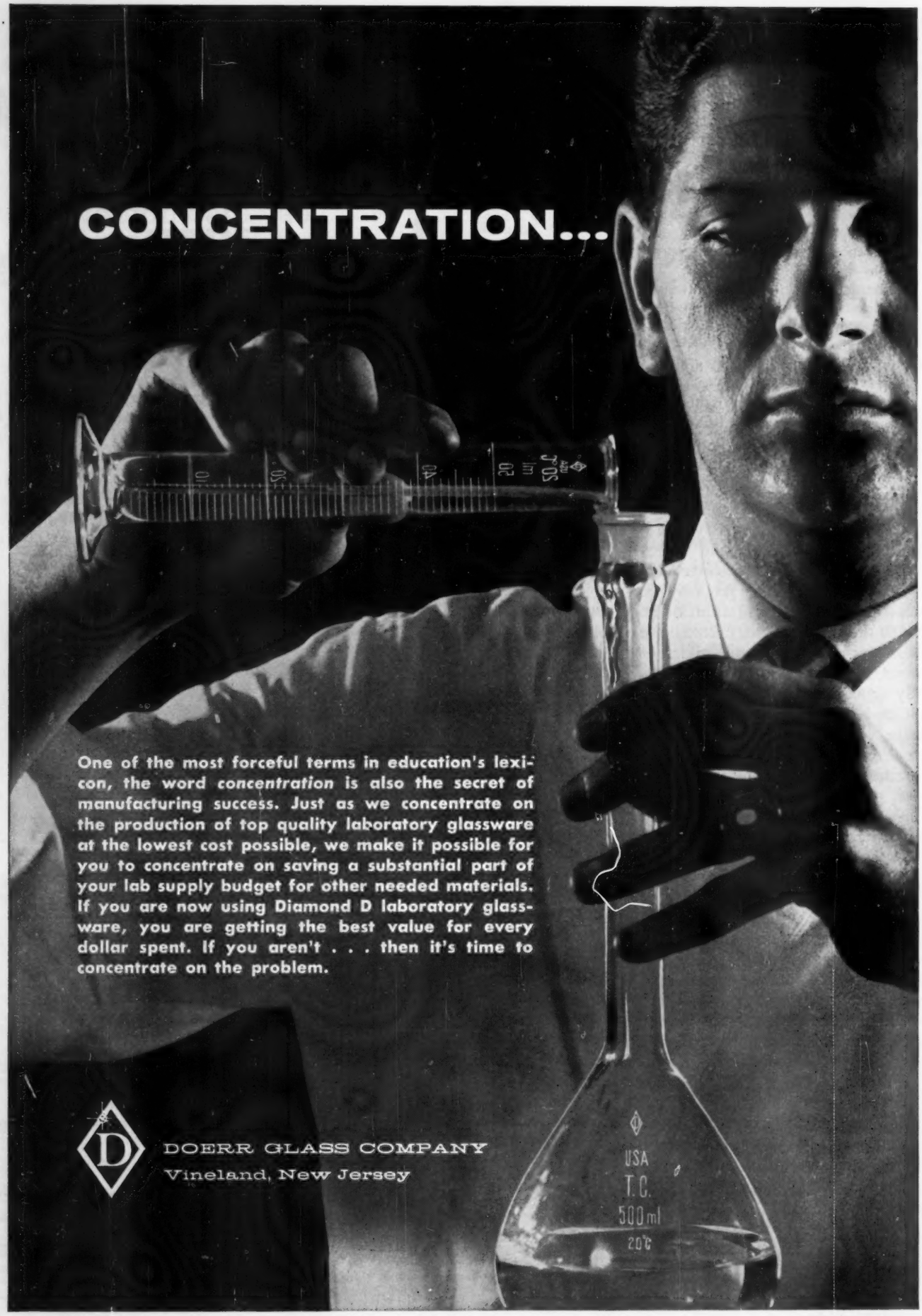
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Stage I are critical. Often many can be changed without altering the events of the episode. The process of determining criticalness is accomplished through experimentation. Various conditions and objects are changed, one at a time, through a series of controlled verbal experiments. The effects of these changes on the events of the episode are noted. Obviously, only when critical conditions are changed, will events change. Thus, experimentally, the child can determine the relevant variables. This is strictly an empirical solution to the problem of causation. It brings the child halfway to the ultimate goal of understanding the causation of events. More complete comprehension includes the recognition of the events as necessary consequences of universal principles that make a certain set of conditions necessary and sufficient. Stage III is devoted to the search for these principles.

Stage III. Eduction of Relations.

Goal: The formulation and testing of theoretical constructs or rules that express the relationships among the variables of the observed physical event.

During this phase, experimentation is still the principal tool of inquiry, but each experiment is designed as a critical test of some hypothetical construct. Obviously, the scope of operations must extend well beyond the domain of the original event. This stage demands a higher degree of conceptual sophistication, flexibility, and imagination than the others. The problem of designing an unequivocal test for an hypothesis can be as taxing as formulating the hypothesis itself. The child sees his objective as the discovery of rules that express the relationship between variables. He learns that the value of any rule he constructs is a function of (1) its validity within a specified realm of applicability and (2) the scope of this realm.

The Method of Inquiry Training

During the past three years the inquiry-training program has evolved into a somewhat structured pedagogical procedure. At the fifth-grade level, ten seems to be the optimum group size. With classes of thirty or more, the remaining children serve as nonparticipating observers who have an important evaluative role. Rotation permits all children to participate in turn. The training sessions are about one hour long and thus far have been held at weekly intervals, although we now believe that more frequent intervals and shorter sessions would be desirable.

Practice, corrective feedback, and exposition are incorporated into each training session. While they are generally applied in a regular sequence, a degree of flexibility in their use is maintained. A typical training session is organized in the following way.

Presenting the Problem

A silent motion picture of a physics demonstration provides the problem episode. Typical of the demonstrations used is the "Collapsing Varnish Can."[3] As any teacher of science knows, children who do not have well-developed, operative concepts of atmospheric pressure and condensation are exceedingly perplexed by this demonstration. In producing the current series of stimulus films—40 demonstrations in all—we tried to capitalize on this perplexity to provide an intrinsic motivation for inquiry. Our technique is predicated on the belief that the drive to "find out why" can surpass in sustained motivational power almost any other classroom incentive.

In addition to their motivational function, the films pose cause-and-effect problems in very specific terms. They make available some parameters and suggest areas where important additional parameters might be sampled. In short, the films provide a portion of empirical experience which the child must then relate to his conceptual systems. To the extent that these systems are not sufficiently developed to accommodate the experience, he must expand and strengthen them through inquiry until he is capable of explaining the episode.

The Practice Session

Immediately upon seeing the film, the children begin the inquiry process. All probes are verbal, originate from the children, and must be so phrased as to be answerable by "yes" or "no." Keeping the inquiry at the verbal level permits the teacher and the rest of the group to keep track of most of the information the children are obtaining. The questions must originate from the children because the selection and design of questions are as much a part of inquiry as the interpretation one makes of the answers. The questions must be answerable by "yes" or "no" because in this way only can the child be discouraged from transferring control of the process to the teacher. "Yes" or "no" questions are hypotheses. The teacher in answering merely establishes the tenability of the hypothesis. If the children were permitted to ask, "Why did the can collapse?" the responsibility for selecting the kind of information to be supplied next would be on the shoulders of the teacher. The children would thus be relinquishing their roles as inquirers by returning to the traditional dependent role of obedient listeners and memorizers. This would inhibit the occurrence of inquiry behavior.

The children have two types of questions available to them as information-gathering tools. In identifying parameters in Stage I they may simply ask questions of verification. Since the film provides stimuli that are one step removed from firsthand experience, the children have recourse to verification questions to confirm or test their hunches as to the identity of objects and their conditions at any given time during the episode. They may also need to check the specifics of the observed events, *e.g.,* what happened when. As indicated previously, adequate verification and identification of parameters is an essential first step.

The second type of probe is the experimental question. The child states a set of conditions and postulates a resulting event. The question is answered by the teacher in terms of whether the postulated event will or will not be the result. If the conditions of the experiment are not complete or clear enough to permit the teacher to give an unequivocal answer, he may say, "That all depends" or "Tell me more." Either of these answers tells the child that his experiment has not been sufficiently controlled. Presumably every experimental question is a test or part of a test of an unstated hypothesis. If the child suspects that the cork in the varnish can was a necessary condition for the collapse of the can, he might ask, "If the cork had not been placed in the mouth of the can before the can

[3] The condensation of water vapor inside a corked varnish can reduces the inside pressure and permits the can to be crushed by the atmospheric pressure.

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was cooled, would the same result have occurred?" The teacher's answer of "no" supports the hypothesis that the corking of the can is a necessary condition and tends also to lend support to an hypothesis that the can must be kept airtight while it is being cooled. *But the child must make these inferences himself from the empirical data he obtains.* He cannot test his hypotheses *directly,* even if such questions are phrased as "yes"-"no" questions. If the child had asked, "Does the cork have anything to do with the collapsing of the can?" the teacher does not answer the question. Such a query tends to tap the *teacher's* understanding of the relationships involved. The child is asking the teacher to make certain inferences *for him* and in so doing is relinquishing some of his own responsibility in the inquiry process. Such questions are frequently asked by children, even after they have been trained for several months. The standard response by the teacher is, "What could you do to find that out for yourself?" This retort, without the slightest note of admonition, puts the responsibility right back where it belongs.

The Critique

Generally the inquiry session is terminated by either the achievement of the objectives, the inability of the children to proceed without further conceptual development, or the expiration of time. The latter is usually the case. Following the inquiry session is the "critique," a period in which the strategy and tactics of the group are reviewed and evaluated by the teacher, the nonparticipating members of the class, and the members of the participating group itself. It has been our practice to tape record each inquiry session and utilize the tapes as a point of departure. But we now feel that this is not entirely necessary, particularly if the critique immediately follows the inquiry session. Immediate "feedback" has long been recognized by psychologists as an important condition for effective reinforcement. Some comments and suggestions by the teacher are best made during the course of the inquiry session itself. If this practice is followed to excess, however, the children may be distracted too often from the physics problem at hand. This may impair their efficiency in this work.

The principal function of the critique

is to correct weaknesses in the inquiry of the children and to build up a repertoire of tactics that will increase their accuracy and productivity. At times, the critique becomes something like a lecture-discussion in which the teacher may be trying to help the group conceptualize the general design of inquiry strategy. Sometimes special recordings of model inquiry sessions are played. These provide clear examples of the strategies and tactics that the teacher wants the children to utilize.

The critique is indispensable; when it is eliminated morale slips and inquiry becomes progressively worse.

Conclusions

Preliminary analysis of the results of three pilot studies suggests the following conclusions about inquiry training.

The inquiry skills of fifth-grade children can be improved over a fifteen-week period as a result of the methods described herein. Most of the children who receive training become more productive in their design and use of verification and experimentation. They develop a fairly consistent strategy which they can transfer to new problem situations. They make fewer untested assumptions; they formulate and test more hypotheses; and they perform more controlled vs. uncontrolled experiments in the course of their inquiry.

The children have little apparent desire to improve their inquiry skills per se. The chief motivating force is the desire to comprehend the causation of the observed episodes. An explanation by the teacher might satisfy this desire, but in the absence of such explanations the children accept inquiry as a means to their goal. Whenever inquiry is not directly related to the satisfaction of their need to "find out why," they show little interest in the strategies and tactics being discussed. Thus methods for constant improvement are desirable.

Our final conclusion for the present is that inquiry skills cannot be successfully taught to this age group as an isolated content area. The major focus in elementary science education should remain the *content* rather than the *methods* of science. Inquiry training and abundant opportunities to attain new concepts *through* inquiry, however, seem to produce increments in the understanding of content as well as an important new grasp of the scientific method and proficiency in its use.

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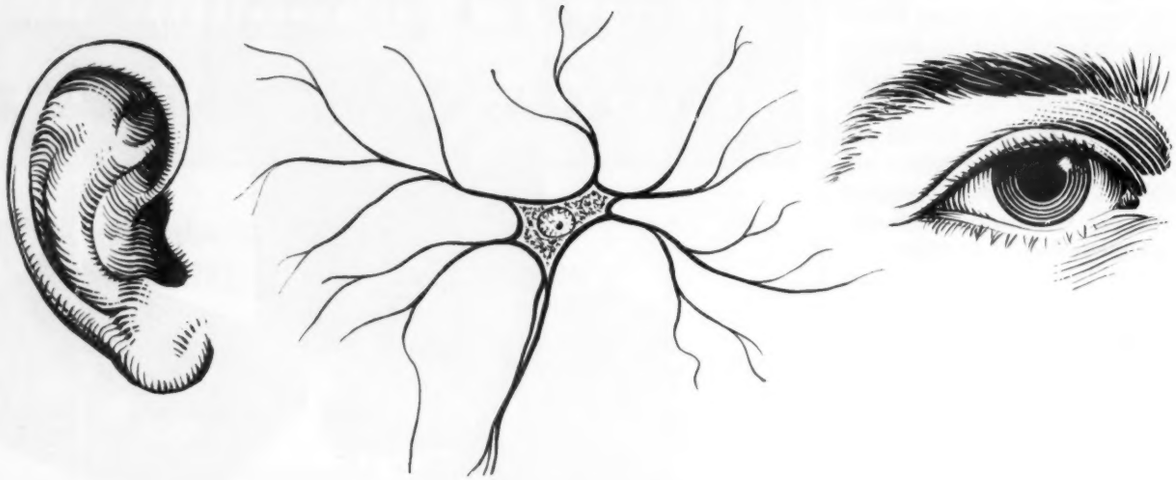


Bell Telephone Laboratories' new electronic "nerve cell" is a step toward finding out

One fascinating area of communications has long resisted exploration—what happens inside the nervous system when you see, or when you hear.

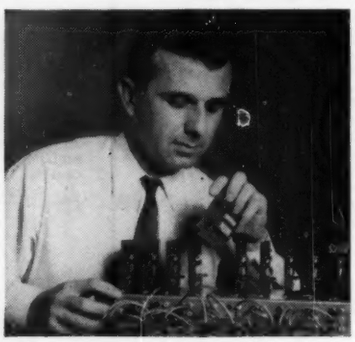
This area is of special interest to telephone science; knowledge of how the nervous system handles sound and picture signals can help determine what information is essential to perception. This in turn may lead to more efficient communication instruments and systems.

To probe the mystery of nerve activity, Bell Telephone Laboratories scientists have developed an electronic model of a living nerve cell or neuron. Consisting of transistors, resistors, capacitors and diodes, the "artificial neuron" exhibits many of the characteristics of a living neuron; for instance, "all-or-none" response and fatigue.

In one experiment at Bell Laboratories, a network of artificial neurons is subjected to a stimulus from light through a set of photocells. The network can distinguish specific patterns of light and dark, thus duplicating roughly some of the eye's basic reactions to light. Similar studies are underway to explore our hearing processes.

At present, too little is known about neural action to permit exact electronic duplication. But experiments with artificial neurons can provide suggestive clues, contributing to a stimulating interplay between electronics and neurophysiology which may help workers in both disciplines.

The human nervous system, including the brain, is the most efficient and versatile data processing system known; and data processing is an essential part of communications. The artificial neuron provides a new approach to investigating and understanding basic nerve network functions. It is a fresh example of how Bell Telephone Laboratories constantly explores new frontiers to improve America's communications system, now and in the years ahead.



Network of neurons is assembled by L. D. Harmon of Bell Laboratories, the initiator of this new research. Many kinds of assemblies are possible.

A single artificial neuron. It delivers electrical impulses when stimulated, like a living cell. Neurons are also being used for research into hearing.

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Biology

The Quantitative Approach in Teaching Biology

By ADDISON E. LEE

Director, Science Education Center, The University of Texas, Austin, Texas

BIOLOGY has long been considered as a purely descriptive science. Observations followed by descriptions constituted the early research contributions in the field. These contributions have been and will continue to be important in teaching biology and the history of biology. It will continue to be important, also, to give students an opportunity to make observations and to describe them accurately.

It should also be recognized, however, that modern biology is quantitative. It attempts to answer the question "Why" as well as the question "What" and in order to do this, one must often ask "How much?" Many of the major breakthroughs in modern biological research have become possible only after quantitative techniques were applied in experiments involving basic questions. These quantitative techniques are the same ones employed in chemistry and physics, but they are now used to answer biological questions. For example, the question of whether the oxygen evolved in photosynthesis came from the carbon dioxide or the water could not be answered until oxygen of two different weights, O^{18} and O^{16}, was incorporated into water and carbon dioxide. These compound substances were then fed separately to photosynthesizing plants, and the oxygen evolved was weighed. It was then determined that the O_2 came from the water. The answer to this apparently simple question had been a puzzle to scientists for a very long time, but when it was finally answered in the early 1940's, a breakthrough of new discoveries on the mechanism of photosynthesis was made possible.

The basic issue in this discussion, however, is to consider the implications of the quantitative nature of modern biology for the high school biology teacher. The teacher can teach about quantitative biology and the history of some of the significant research contributions, such as the one described above. But the biology teacher today can indeed go much further than that. He can provide opportunities for students to make actual measurements, to interpret them, and to ask questions and find the answers to them. To find the answer, it may be necessary to make both observations and measurements. In short, this is the experimental approach which may be the touch needed to provide both information and interest for high school biology classes.

Specific examples of the quantitative approach follow. These examples vary in complexity, and thus illustrate the fact that the study of quantitative biology is not limited to advanced or very bright students, but can be adjusted to different ability levels. Advanced exercises for the bright students, however, should not be overlooked.

1. How to Interpret What You See in the Microscope.

A. The microscope is an instrument which permits us to see a world of things — living and nonliving — too small to be seen with the unaided eye. Because of the small size, we employ measurements to describe these tiny things not commonly used to describe objects in our everyday visible world. All of you know how long one inch is, but biologists describe things in terms of millimeters, microns, and millimicrons. One micron is equal to .001 mm or 1/25,000 inch; 1000 microns equal 1 mm; 25,000 microns equal 1 inch. Using this information, complete the table below, converting each measurement to millimeters, millimicrons, and inches.

B. You can take measurements with your microscope. There are special discs with finely etched scales which can be placed in the eyepiece and used for accurate measuring. Rough estimations of sizes, however, can be obtained by a much simpler technique. Obtain a bright field—the circular view under the microscope—and slide a thin, plastic millimeter ruler about halfway across the field. You can then focus on the millimeter markings and determine the diameter of the field under both low and high power. Record the results.

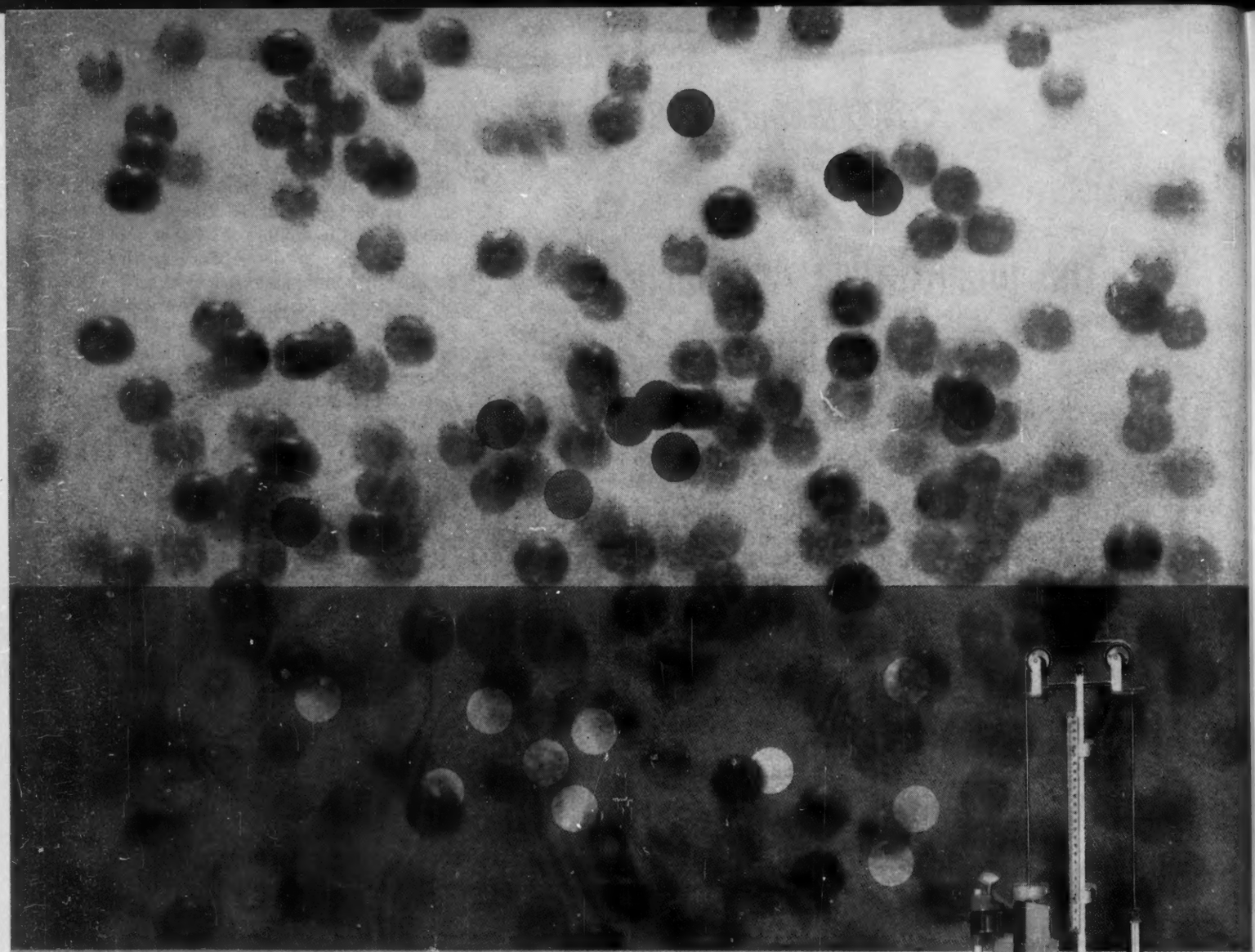
Diameter of the Microscopic Field

Low Power_____ High Power_____

Using this information, determine measurements of several materials studied under the microscope—for example, the tiny plants and animals you may see in a drop of pond water on a slide. Record your results.

C. It is also important to be able to put together in your mind the appearance of a whole object if sections are seen in a transverse, or cross-section

Cells	*Approximate Diameter*			
	Millimeters	*Microns*	*Millimicrons*	*Inches*
Ostrich egg		80,000		
Parenchyma cells from fruit		1000		
Amoeba		100		
Liver cell		20		
Meristem cell from onion root		17		
Red blood cell		7.5		
Prodigiosus bacillus		0.7		
Typhus fever rickettsia		0.5		



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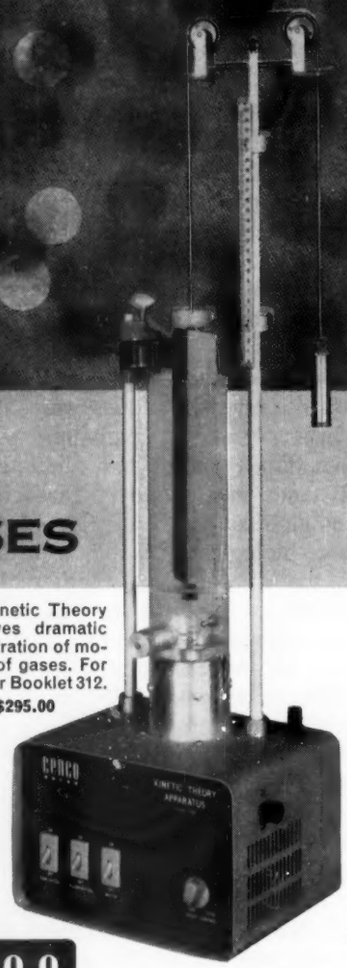

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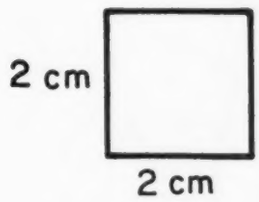
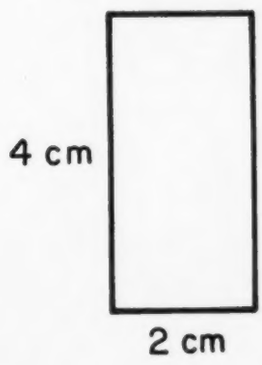
view and in a longitudinal, or long-section view.

Suppose a box had a cross-section view like this:



And a long-section view like this:

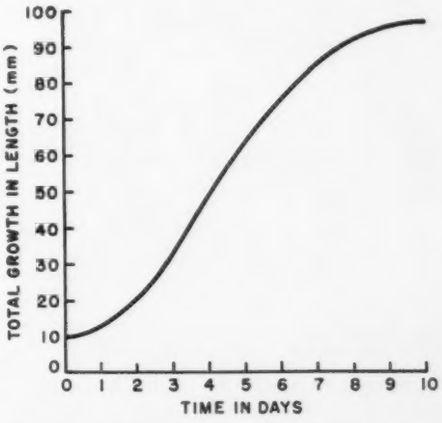


Make a three-dimensional drawing of such a box in the space below.

Remember, when you are observing materials on slides already prepared, you need to find out whether you are observing a *whole mount,* a *cross-section slice,* or a *long-section slice* before you reach any conclusions concerning the material you are observing. You should also find out whether the material has been stained in its preparation. Stains are very useful in the preparation of material to enable some parts to be seen better, as well as to test for some materials. You should recognize, however, that in such cases the color is artificial and may not be the true color of the untreated material.

2. How to Read Quantitative Data.

A. Data obtained on daily measurement of the total growth of a root tip were plotted to give the following graph:



Draw on the above graph the approximate curve which would be produced if daily increments of growth were plotted.

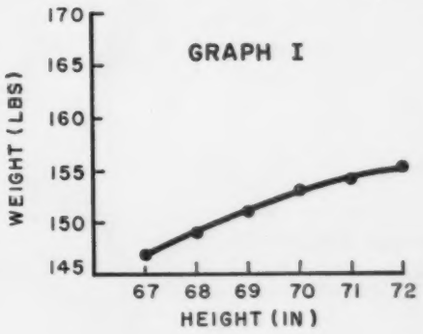
B. The following curves illustrate the amount of growth in length of roots given experimental treatments compared to a control grown under a standard set of conditions.

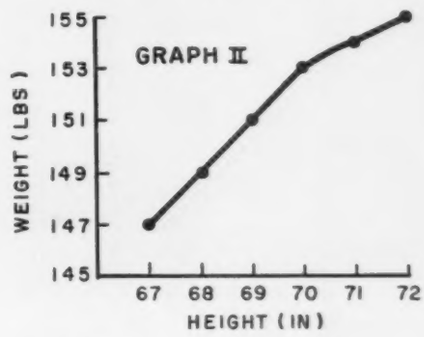
Write an interpretation of these results.

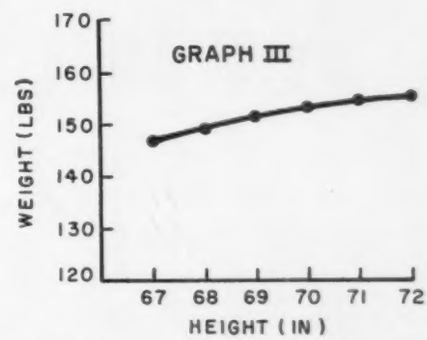
C. The data given below are the heights in inches and the weights in pounds of a group of men.

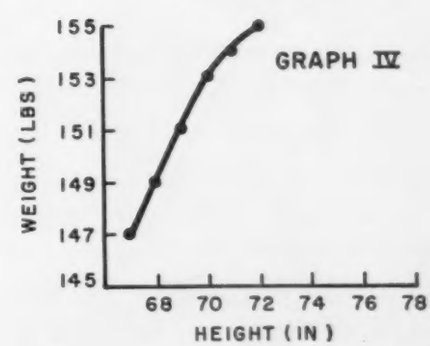
Weight	Height
147	67
149	68
153	70
151	69
155	72
154	71

Which one(s) of the following graphs represent the data plotted correctly?









Newton had his falling apple

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3. Drawing Conclusions from Quantitative Data.

A scientist determined the amount of carbon dioxide released by a variety of fresh vegetables when kept at a constant temperature of 30° C from the second to the twenty-sixth hour after harvesting time.

From the weight of carbon dioxide released, it is first possible to calculate the amount of carbon lost and then the amount of glucose lost. The results are given in table below.

Evaluate the proposed interpretations listed by number below according to the following key:

A. A sound conclusion based on this experiment and this experiment only.

B. Goes beyond the data given, but is probably true on the basis of other facts you know.

C. Goes beyond the data given, but is probably untrue on the basis of other facts you know.

D. Goes beyond the data given, and you cannot decide whether it is probably true or untrue.

E. Contradicted by the data given.

1. Protoplasm in the cells of tomatoes remains alive after the tomatoes are picked.
2. The rate of respiration in some fresh vegetables kept at 30° C is greater during the second twenty-four hours after harvesting than during the first twenty-four hours.
3. Asparagus contains a higher per cent of water than carrots.
4. Vegetables containing a high per cent of dry matter consistently respire more rapidly than those containing a low per cent of dry matter.
5. Glucose contains material—chemical elements—other than carbon.
6. The rate of respiration of the fresh vegetables in the experiment is influenced by factors other than the per cent of dry matter present.
7. These vegetables lose less glucose when held in storage at 30° C than when held at 35° C.
8. These vegetables decrease in value as human food when held at 30° for twenty-four hours after picking.

These are but a few examples serving only to introduce and illustrate the quantitative approach which should permeate the entire biology course—classroom discussion, laboratory activities, and individual study. This was the primary approach of the National Academy of Sciences-National Research Council Committee Writing Conference, which produced the *Sourcebook of Laboratory and Field Studies for Secondary School Biology*, now being published through Holt, Rinehart and Winston, Inc. Many other examples using the quantitative approach are given in this book. The quantitative approach also characterizes much of the program now being developed by the Biological Sciences Curriculum Study of the American Institute of Biological Sciences. But what is more important, the quantitative approach characterizes modern research in biology. If modern research has any implications—as indeed it must—for our developing curriculum, we must be prepared to use this approach.

The modern biology teacher and his students must be able to make measurements, read measurements, interpret them, and draw sound conclusions from them. These are the essential ingredients of the experimental approach which pushes back the frontiers of our knowledge and leaves us with real and important contributions.

	Dry Matter	*Weight of CO_2 Evolved**	*Weight of Carbon Lost**	*Weight of Glucose Lost**
	Per Cent	*Grams*	*Grams*	*Grams*
Asparagus	8.3	20.066	5.473	13.682
Lettuce	6.2	9.424	2.570	6.425
Carrot	13.9	4.659	1.271	3.178
Tomato	6.1	3.920	1.069	2.672
Red pimento	9.4	1.897	.516	1.290

* Per 100 grams of dry matter.

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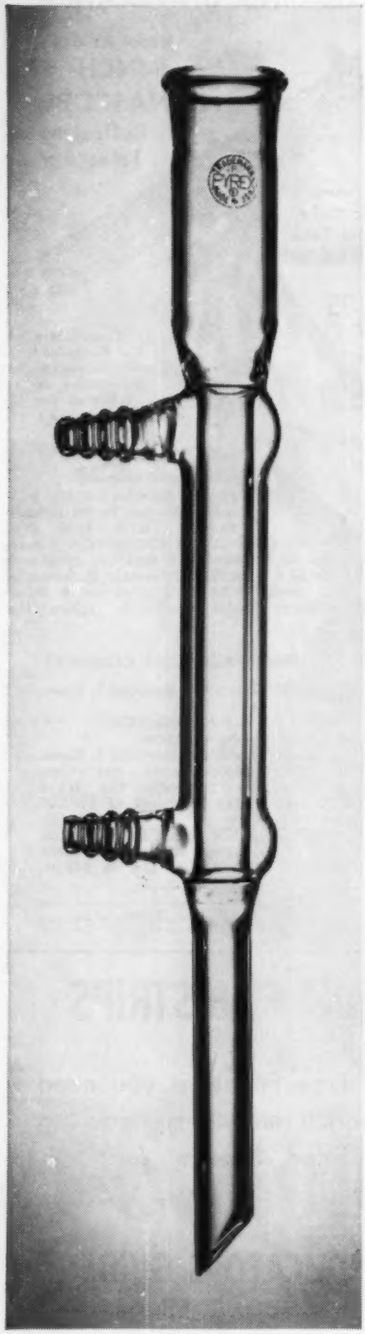

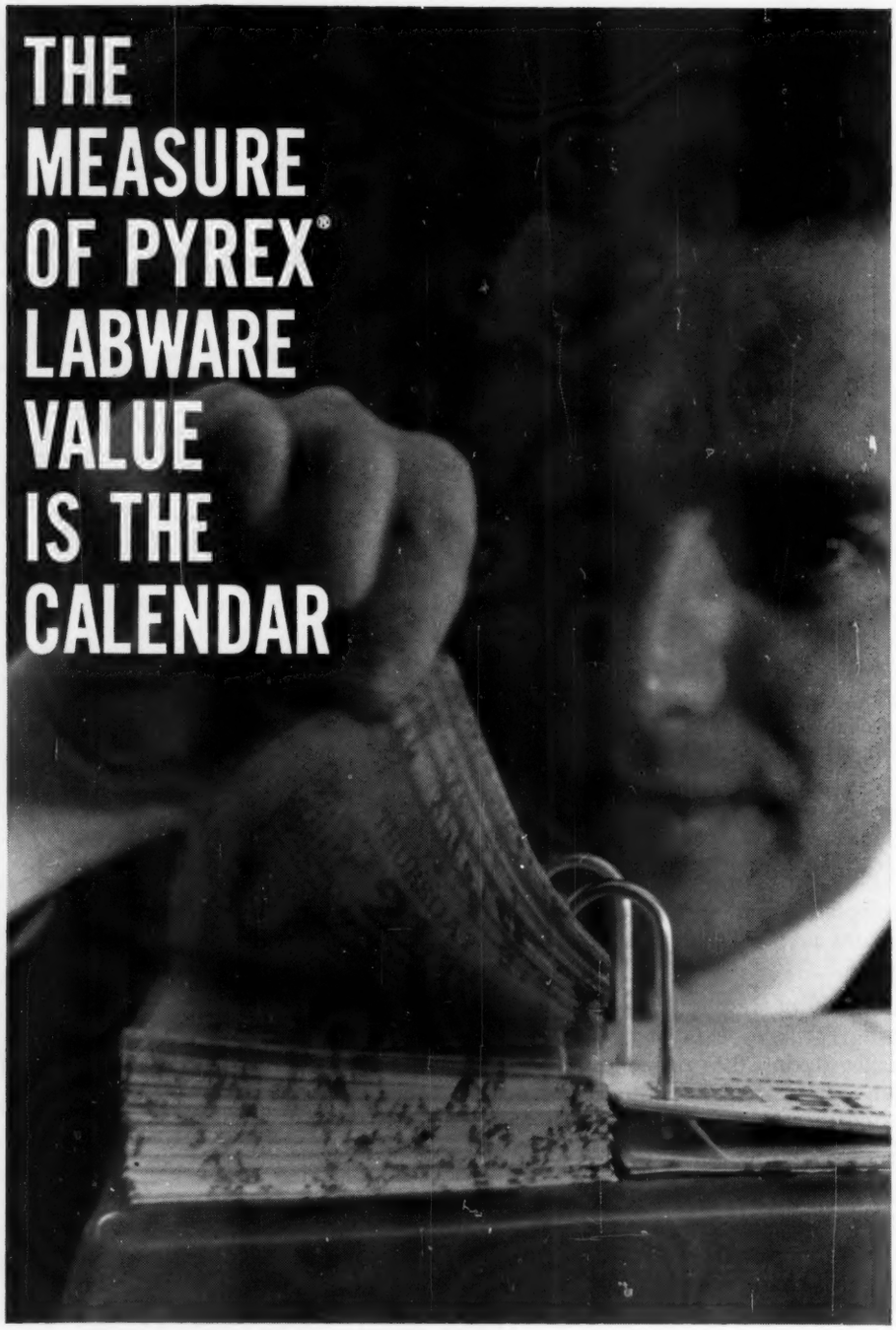

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Chemistry

Opportunity in Junior High Science

By HARRY CRESSMAN

Science Teacher, Hicksville Public Schools, Hicksville, New York

IN conversing with young people both in science classes and outside of science classes, a strong feeling persists with me that many pupils are ready for meaningful experiences in science far sooner than we may have been accustomed to suppose or to demonstrate in practice. Further, I am convinced that they are desirous and capable of more intense knowledge and greater depth of understanding of the natural laws which control their environment.

This conclusion undoubtedly is not peculiar to me, but rather is or has been an experience of many people, both teachers and nonteachers. What may make this strong opinion unique with me is that for the past two and one-half years, I have been in a position to determine whether or not there is any validity to the fact that pupils in junior high school are capable of doing more.

In September 1957, a pilot science program was organized in the public school system of Hicksville, New York, to determine what these meaningful science experiences might be; to select those scientific concepts which pupils at various grade levels could follow; and to demonstrate those natural laws which could be learned without the experience of frustration and failure in exploring new ideas. At the same time developing and/or strengthening desirable attitudes toward science is a part of the program. In short, we were interested in trying to determine as objectively as possible and in a real teaching situation what can be taught, to what grade level it can be taught, and to what depth we should try to teach it.

The first phase of the program for a general chemistry course began with selected groups of fourth- and seventh-grade pupils. A serious and sincere attempt was made to select those pupils whom we thought could profit most from this experience. Consequently, we used all the available information and what we felt was the most pertinent data about the children in making the selections. The criteria used were the intelligence quotient, reading and arithmetic ability, past scholastic record, teacher comments, parental consent, and finally and most important, the pupil's interest and willingness to participate in the program.

At the elementary school level, the plan was to start with a group of fourth-grade pupils and continue with them through the fifth and sixth grades. This group completed their phase of the program in June 1960.

At the junior high school level, the plan was to start with a group of seventh-grade pupils and continue with them through the eighth grade. This group of junior high school pupils completed their program in June 1959. The following information pertains to them.

TABLE I

Number of Pupils in Program	*Boys*	*Girls*	*Totals*
At Beginning of Seventh Grade	42	27	69
At Beginning of Eighth Grade	28	18	46
At End of Eighth Grade	28	18	46

The number of pupils who began the program in the seventh grade represented 7.2 per cent of the total seventh grade. The number of pupils who completed the program at the end of their eighth grade represented 7.1 per cent of the total eighth grade. Due to a decrease in the eighth-grade enrollment the percentage remained about the same.

The drop-outs are accounted for in the following manner:

1. Eight pupils dropped out of the program within the first month of the program in the seventh grade because of conflict of interest and scheduling of this fifth major subject.

TABLE II

Abilities of Selected Students

General Ability of Pupils Selected for Program			*Boys*			*Girls*		
			Median	Q_1	Q_3	*Median*	Q_1	Q_3
Intelligence Quotient		Quit Program	122	120	128	115	114	127
		Completed	129	122	136	122	119	131
Reading	Vocabulary	Quit Program	1.9	1.7	2.5	2.2	2.0	2.5
		Completed	2.4	1.8	3.5	2.2	1.4	2.5
	Comprehension	Quit Program	2.4	2.0	3.0	1.8	1.8	3.0
		Completed	2.3	2.3	3.0	2.3	1.8	3.0
Arithmetic Reasoning		Quit Program	1.5	.9	1.8	1.1	.7	1.4
		Completed	1.8	1.6	2.5	1.4	.7	1.9
Past Scholastic Average		Quit Program	91	90	92	90	90	93
		Completed	92	91	93	93	93	94

2. Seven pupils moved from the district.
3. Four pupils dropped out because of loss of interest in the program.
4. Four pupils dropped out because they found themselves in a program beyond their abilities.

Incidentally, since this subject constituted a fifth major subject for these pupils and was not needed to complete their junior high school program of studies, they were permitted to drop the chemistry at any time and for any reason. Significantly enough, in spite of this freedom to remain a part of the study, only eight pupils chose to drop out and this was done during the first year of the two-year program. All who started the more difficult second year of the program persisted to the end.

The figures used in connection with the vocabulary, comprehension, and arithmetic reasoning were determined at the end of the sixth grade and refer to the number of years above actual grade placement in these areas.

Intelligence quotients were obtained from scores on the California Mental Maturity Test. Reading and arithmetic achievements were determined from scores on the California Reading and Arithmetic Achievement Tests.

TABLE III

Test Form	*Groups Compared*	*Number of Pupils*	*Median*	Q_1	Q_3	Q_3-Q_1	*Range*
N	Eighth/Group A	44/523	93/50	83/25	96/75	13/50	62-99
	Eighth/Group B	44/3265	88/50	76/25	95/75	19/50	43-99
	Eighth/Group E	44/7164	89/50	78/25	94/75	16/50	47-99
1959	Eighth/Group A	44/590	92/50	87/25	95/75	8/50	66-99
	Eighth/Group B	44/3597	85/50	73/25	91/75	18/50	35-99
	Eighth/Group E	44/8202	86/50	75/25	92/75	17/50	38-99

The body of scientific knowledge classified as general chemistry was chosen as the content for the program, both at the intermediate and junior high school levels. During the seventh grade of the two-year program, pupils were instructed in that science content which we thought gave them the necessary background and attitude toward the proposed course content of the eighth grade. During their eighth grade, these pupils were then exposed to a general chemistry course as outlined in the Chemistry Syllabus of the Bureau of Secondary Curriculum Development of the New York State Education Department.

While engaged in the chemistry course during their eighth-grade studies, pupils were subjected to the same rules and regulations as any senior high school pupils who were taking chemistry for New York State Regents credit. They attended a chemistry class once a day for fifty minutes, five days per week, and a one-hour laboratory period once a week after school hours. Moreover, this laboratory period was conducted in the chemistry laboratory of the senior high school, several blocks away from the junior high school. Here, these pupils used the same facilities, equipment, and materials as the senior high school chemistry pupils. During their eighth grade, the pupils in the program spent the same amount of time in recitation and laboratory as the senior high school pupils. They used a recognized senior high school chemistry textbook and laboratory manual-workbook combination. Incidentally, all of this was in addition to their normal junior high school program of four major and several minor subjects.

At the completion of the program, results were evaluated in terms of the

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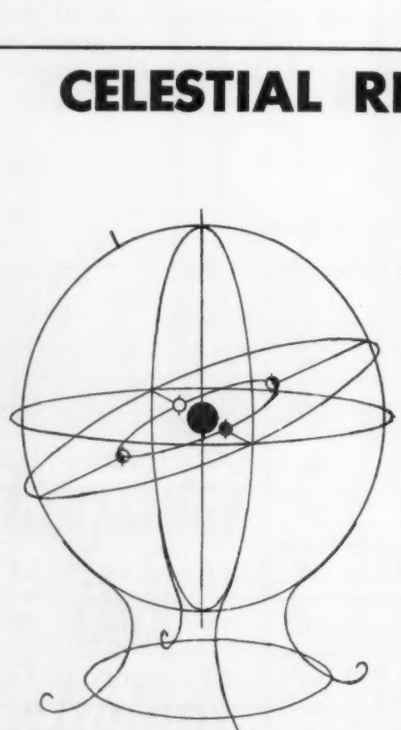

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TABLE IV

Test Form	*Groups Compared*	*Median*	Q_1	Q_3	Q_3-Q_1	*Range*	*Row*
June 1959	Eighth / NY State	80 / 76	75 / (75)	90 / 85	15 / 20	30-98	A
	Eighth / NY State	75 / 65	64 / (40)	90 / 84	26 / 44	?-99	B

American Chemical Society Chemistry Examination and the New York State Regents Chemistry Examination.

Results on the American Chemical Society Examination

In June 1959, forty-four pupils took the American Chemical Society examination, Form N and Form 1959, according to instructions accompanying these tests.

Table III contains a comparison of the performance of the eighth-grade pupils with Groups A, B, and E of the Test Norms on the American Chemical Society Examination, Form N and Form 1959. (Percentile ranks compared.)

Incidentally, part of the group took Form N first; the remainder took Form 1959. All pupils took both forms of the test. The coefficient of correlation between the eighth-grade scores on Form N and Form 1959 was .95.

Group A consists mainly of juniors, with a few sophomores and seniors, who have had zero to two semesters of mathematics prior to taking the test. The nation-wide returns cover public and private schools.

Group B consists of juniors only having four to six semesters of mathematics but no physics prior to taking the chemistry course. Again nation-wide returns cover both public and private schools.

Group E consists of a random sample from the total nation-wide returns on the American Chemical Society Test, public and private schools.

Results on the New York State Regents Chemistry Examination

On June 17, 1959, forty-four pupils, along with the senior high school chemistry pupils, took the New York State Regents Chemistry Examination. They wrote their examinations according to the same rules and regulations. Their papers were scored, and, along with the senior high school chemistry papers, were sent to the New York State Education Department in Albany to be rechecked. The marks remained as originally recorded with the exception of three papers. On these papers the score was increased by a point in one case and lowered by one and two points, respectively, in the other two cases.

Table IV contains a comparison of the performance of the eighth-grade pupils with the pupils throughout the State of New York who took this New York State Regents Chemistry Test on June 17, 1959. (Test scores compared in Row A. Percentile ranks compared in Row B.)

Circled scores indicate the lowest passing test score and percentile rank. Coefficients of correlation between the eighth-grade scores on the American Chemical Society Test (Group B), Form N and Form 1959, respectively, and the New York State Regents Chemistry Test were .77 and .72.

On the basis of these two tests, one which permitted us to compare the eighth-grade group with chemistry pupils across the country and the other which permitted us to compare these same pupils with chemistry pupils across the State of New York, half of the eighth-grade pupils did better than 85 per cent of the students who took the Form 1959 American Chemical Society Test and better than 75 per cent of the students who took the June 1959 New York State Regents Chemistry Test. Thirty-nine of these pupils qualified for New York State Regents credit in chemistry.

Finally, if interest and self-motivation as evidenced by participation in class and laboratory work are criteria for determining readiness for a subject, then these pupils were definitely ready. If performance on nationally recognized examinations in chemistry is a sufficient and acceptable indication of a pupil's capabilities in the subject, the scores achieved on these tests by almost the entire group proved that a significant number of eighth-grade pupils are ready and able to pursue the study of chemistry to a much greater depth and a much broader scope than is or can be done in a general science class. Moreover, eighth-grade pupils can perform on a level with senior high school pupils in current courses of study in senior high school chemistry. Why not give these pupils the opportunity, at every level, to go faster and farther in a science program worthy of their interests and abilities?

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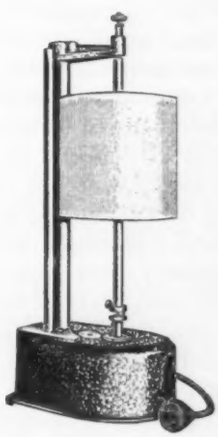

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The Elementary School Science Reporter

Certification of Elementary School Teachers

By HAROLD E. TANNENBAUM

Professor of Science Education, State University College of Education, New Paltz, New York

SINCE the summer of 1959, people all over the country have been hearing about the "New Horizons Project of the National Commission on Teacher Education and Professional Standards (TEPS)." This reporter, very much concerned with the preparation of elementary school teachers, went to the TEPS conference in San Diego in June 1960 as one of the NSTA representatives.

People representing various educational institutions were present. Kindergarten teachers and chemistry professors worked side by side with college deans and high school English teachers. This was made possible because of the co-operation of nine large influential professional associations and more than sixty affiliated groups—all those concerned with teacher education. Just as had happened at the two previous co-operative meetings (the conferences held at Bowling Green, Ohio in 1958 and at Lawrence, Kansas in 1959), the sessions proved to be stimulating and productive. For example, the *New York Times* of July 24, 1960, reported the following:

> All persons who serve in an educational capacity in a school or institution of higher learning—whether public, private, or parochial—should hold a state license or certificate . . .
>
> The project also proposed a six-year preparatory program for future teachers. This would include five years of college preparation emphasizing the liberal arts, subject specialization, and study of educational practice and theory, and a half year of internship under the institution's supervision.
>
> After this, the prospective teacher would be required to demonstrate his competence on the job during a one-year probationary period.

But we are interested in what was proposed with regard to the requirements for the education of elementary school teachers generally, and in what was recommended for their special education in the area of science. Specifically, nothing! Yet underlying all the discussions and implicit in every statement were suggestions for a new kind of education for all of America's teachers—with an insistent note that the elementary school teachers should be as well prepared as the college or high school instructors.

Just before the San Diego meeting, the AAAS* Co-operative Committee on the Teaching of Science and Mathematics recommended the adoption of certain certification standards for the high school science teachers. (*Science,* April 8, 1960.) While the recommendations varied with the subject area, they can be summarized by noting that the AAAS Committee advocated that approximately sixty hours of science and supporting areas be studied by the prospective teacher during his four-year undergraduate course, and that an additional thirty hours of science and supporting areas be taken during a fifth year of study.

*American Association for the Advancement of Science.

And on June 17, John Mayor, Director of Education for the AAAS, writing the editorial for *Science,* stated:

> Subsequently, in the four-day San Diego conference of the National Commission on Teacher Education and Professional Standards . . . scientists and educators again will work together in planning improved teacher-certification programs.

So we have some things brewing for the secondary school teachers. But no such specific recommendations have yet been made for the elementary school teachers, at least not by the large national organizations.

On the other hand, many people at San Diego presented ideas which deserve attention. In analyzing the discussions, we find that people were recommending a five-year program of studies for all elementary school teachers with a breakdown about as follows:

Liberal studies	110 semester hours
Humanities	
Social Sciences	
Natural Sciences	
Professional Education	30 semester hours
Child Growth and Development	
Curriculum (including the teaching of science and mathematics)	
Philosophy of Education	
Evaluation and Measurement	
Internship	15 semester hours

It is certainly a formidable proposal. Imagine every elementary school teacher with thirty or forty hours work of college science and mathematics *before* he starts to teach, and in addition to this firm background in the liberal studies, a solid background in professional studies.

But these quantitative aspects of the proposal were the least of the matters perhaps under consideration. Everyone who spoke on the subject stressed that simply counting semester hours of credit was no way to measure the preparation of any teacher, especially an elementary school teacher. The quality of the courses needed for the preparation of a teacher was the subject of continual consideration. The most succinct and most general statement on quality was that *all* of the courses, both liberal studies and professional education,

which any student takes must be worthy of his college education. Someone put it this way: "Every liberal arts course, well taught, becomes a part of the professional education of the prospective teacher. And, conversely, every professional course, well taught, becomes part of the liberal education of that same young teacher."

What seems to be coming then is a complete revision of the curricula of American teacher education programs. Each young teacher will need to study much more before he is certified as a teacher. Elementary school teachers will come into the profession with a sound and a broad background in the various sciences and in mathematics, and his college courses will be better taught. The fact is that the elementary school teacher of the future is likely to have a broader background in science than do many of our present high school science teachers, due to the "New Horizons Project."

As a regular feature of *The Science Teacher*, the calendar will list meetings or events of interest to science teachers which are national or regional in scope. Send your dates to *TST*'s calendar editor as early as possible.

November 6-12, 1960: American Education Week. Theme: Strengthen Schools for the 60's

November 24-26, 1960: 60th Convention, Central Association of Science and Mathematics Teachers, Statler-Hilton Hotel, Detroit, Michigan

December 26-30, 1960: NSTA Annual Winter Meeting in conjunction with 127th meeting of the American Association for the Advancement of Science, the Roosevelt Hotel, New York City

February 1-4, 1961: Annual Meeting, American Association of Physics Teachers, Hotel New Yorker, New York City

February 22-25, 1961: 34th Annual Meeting, National Association for Research in Science Teaching, Pick-Congress Hotel, Chicago, Illinois

March 24-29, 1961: NSTA Ninth Annual National Convention, Hotel Sherman, Chicago, Illinois

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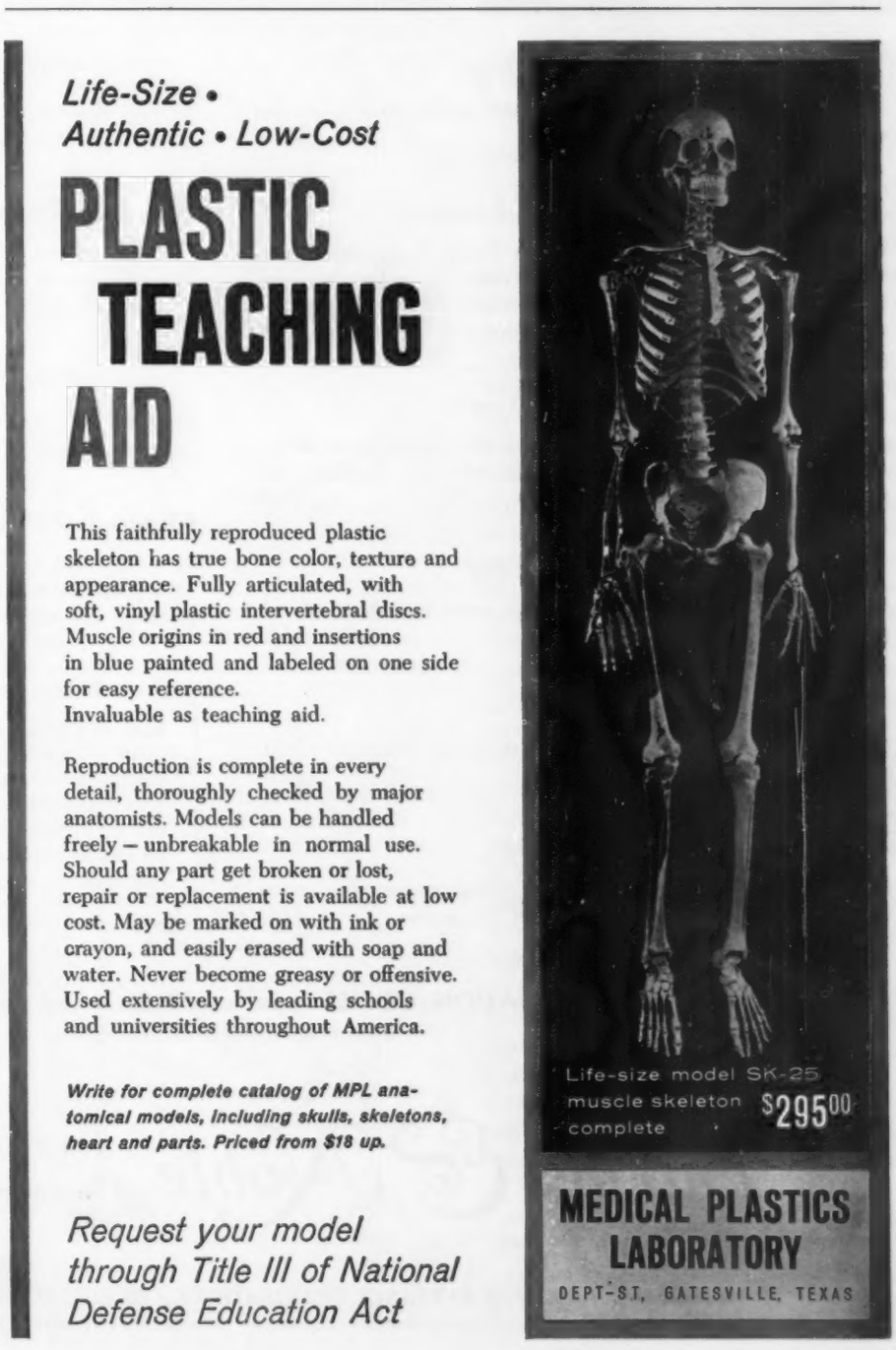
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Classroom IDEAS

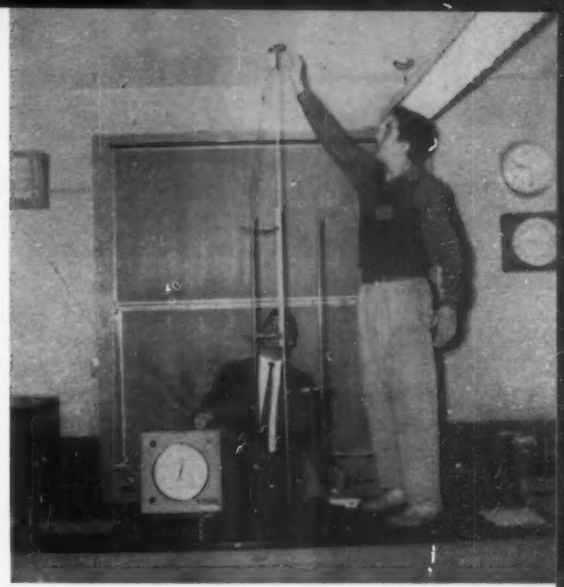
Physics

Determining the Value of "g"

By PHILLIP CROSBY, Northeastern University, Boston, Massachusetts, and WENDELL F. BENNETT, Natick High School, Natick, Massachusetts

Perhaps no table or book value is taken for granted as much in high school and college physics as the acceleration of gravity. A search of high school laboratory manuals and high school and college physics textbooks reveals an almost complete indifference to any interest that a student or physics teacher might have in the laboratory determination of "g." High school laboratory manuals mention the value for the acceleration of gravity under the experiment on the pendulum, while textbooks only define "g," and do not attempt to explain how its value is obtained.

Although the value for "g" may be obtained in the pendulum experiment as a by-product of that experiment, most physics teachers will go no further in determining "g" experimentally. In college or secondary schools with sufficient budgets, however, an Atwood machine may be available. This instrument is expensive but does produce a satisfactory result for determining "g."



Author Crosby, with student standing on table, prepares to experiment.

Other methods for determining "g" which utilize less expensive equipment have been suggested by the Physical Science Study Committee in connection with their rejuvenated high school physics program.[1] In the least expensive of the two recommended methods magnetic tape falls between the poles of an electromagnet. Although this method produces very satisfactory results for "g," it involves the use of a tape "developer" before results may be determined, a cumbersome and time-consuming method.

The second method is more interesting, more immediate, but also more expensive. With a stroboscope, a timer, and a Land camera, the finished picture of a falling body may be obtained in a matter of minutes and with very good results. The room must be darkened, however, to use the camera.

The simplest method that we have been able to find in the literature investigated employs an electromagnet, a steel ball, and a turntable run by a synchronous motor, geared down so that the table makes one revolution per second.[2] Although this apparatus ap-

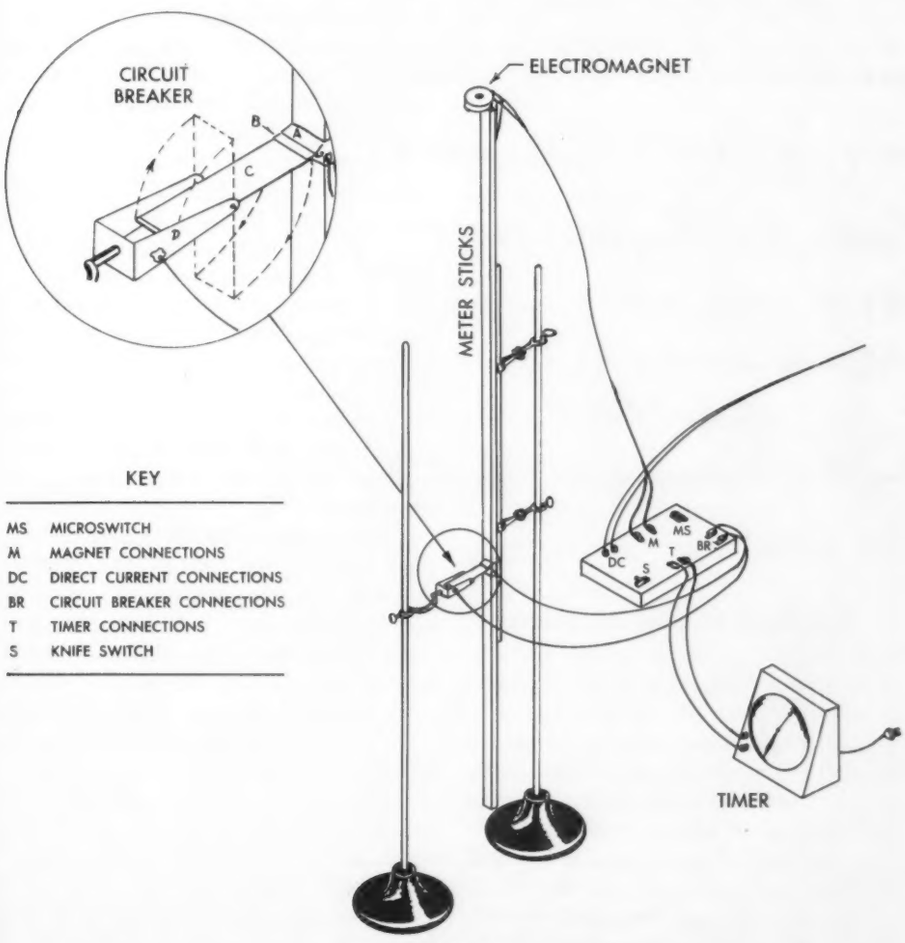


FIGURE 1.

[1] "A Symposium: The Physical Science Study Committee." *Harvard Educational Review*, 29:1-36. Winter 1959.

[2] Harvey E. White, with the assistance of Eugene F. Peckman. *Laboratory Exercises for Physics*. D. Van Nostrand Company, Inc., Princeton, New Jersey. 1959. p. 11.

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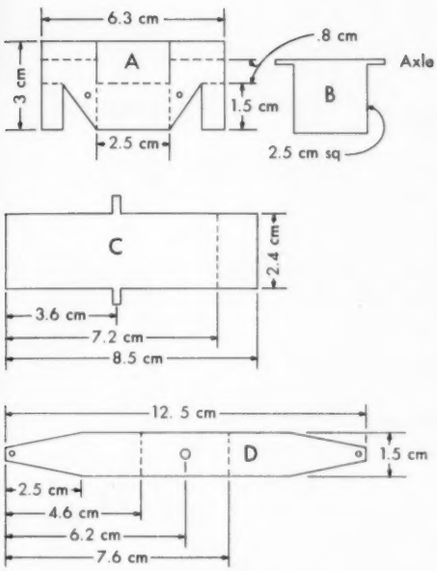

FIGURE 2.

pears to have considerable merit, it still does not satisfy the desire for an uncomplicated, but accurate, measuring device.

An Electromagnetic Free-Fall Apparatus

Simple, inexpensive apparatus is a necessity for the high school physics laboratory. With this thought in mind the authors devised a free-fall apparatus which satisfies both requirements. The materials needed are indicated in Figure 1. The electromagnet measured about 1.5 cm internal diameter; the steel ball measured slightly less.

The key to the apparatus is the circuit breaker and slider. Details of the circuit breaker are shown on the inset in Figure 1. Details of the slider and other components of the breaker are indicated under the construction patterns for the breaker parts, Figure 2A, B, C, and D. All parts of the breaker apparatus were made out of sheet iron.

The initial circuit breaker was extremely simple, but produced a high error in our results—two per cent. It was a friction-catch idea, based on the same principle as a cupboard door catch. Because the length of fall is very short, the delay caused by friction produces a relatively high error.

Another source of error was found in the switch. Initially, a homemade switch was used with fairly satisfactory results, but a microswitch taken from some discarded war-surplus equipment was substituted for an improvement.

A control box was made to reduce cumbersome wiring and to facilitate rapid assembly of the apparatus. Binding posts, appropriately marked, were provided for the corresponding lead wires, also marked. The wiring diagram for the control box is shown in Figure 3.

Operation of Apparatus

To operate the apparatus, connections are made as indicated in Figure 1. The slider is set at the desired height on the meter stick so that the breaker plate C barely makes contact with, and is supported by, the flap B on slider A. The timer is turned on and set at zero; switch S on the control box is closed activating the electromagnet (coil); and the ball is placed inside the core of the coil where it is supported by the magnetic field of the coil.

As soon as the steel ball is in place, the microswitch is closed thus breaking the circuit through the coil, causing the ball to fall, and starting the electric timer. The ball striking the breaker plate C breaks the circuit through the timer and stops it. The time of fall is then read directly from the timer, the height of fall from the meter sticks. The value for the acceleration of gravity can be calculated from the observed readings. Typical results are indicated in Table I.

TABLE I

Distance (cm)	*Time (sec)*	*g (cm/sec²)*	*Per Cent Error**
10	0.144	966.0	1.56
30	0.245	1000.0	1.96
50	0.316	1000.0	1.96
70	0.379	976.0	0.44
90	0.431	970.0	1.04
110	0.476	975.0	0.54
130	0.517	975.0	0.54
150	0.555	978.0	0.24
170	0.590	977.0	0.34
190	0.622	981.9	0.155

* Using "g" for Cambridge, Mass. as 980.4 cm/sec².

Increasing Accuracy of Apparatus

When setting up the apparatus, it is essential that it is plumb, enabling the steel ball to strike the breaker arm. A homemade plumb can be made with a string and weight, or a carpenter's level may be used, if one is available.

The breaker should be adjusted so that the breaker plate C does not have more than one mm projecting under the slider flap B, and the ball can hit the breaker plate near the flap, but not on it. This increases the lever action and speed of breaking the circuit.

Care should be taken in determining the height of the fall, making certain that measurements are made from the bottom of the ball, when it is being supported by the magnetic field of the energized coil, to the slider flap B. For short heights this becomes critical. Greater heights reduce the inherent experimental error, however, and the "sucking coil" height of the ball becomes less critical. Although it is cumbersome to set up and align, students are interested in finding out what results they can get if the ball falls from the ceiling to the breaker. A trial experiment resulted in the following:

Distance of fall	300.0 cm
Time of fall	.782 sec
Value of "g"	981.6 cm/sec²
Error	0.12 per cent

Summary

All physics students are well acquainted with the value for the acceleration of gravity, but few, either in high school or college, can explain how this important value is obtained experimentally. The apparent lack of consideration given to experimental derivation in high school and college texts, and in high school laboratory manuals, stems from the fact that no simple apparatus is generally available to use for the determination. This paper is an attempt to satisfy that need. It is hoped that other physics teachers may find the apparatus described herein simple, inexpensive, and accurate.

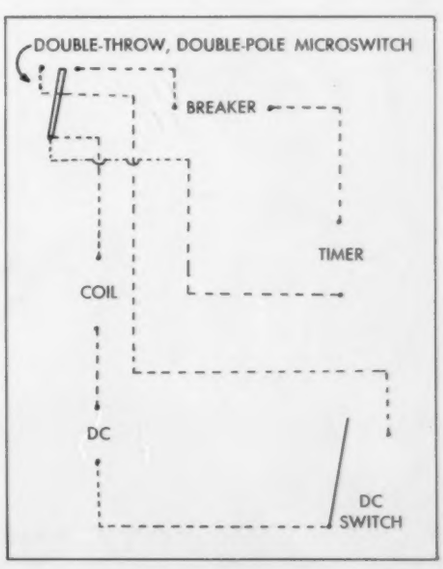

FIGURE 3. Control Box

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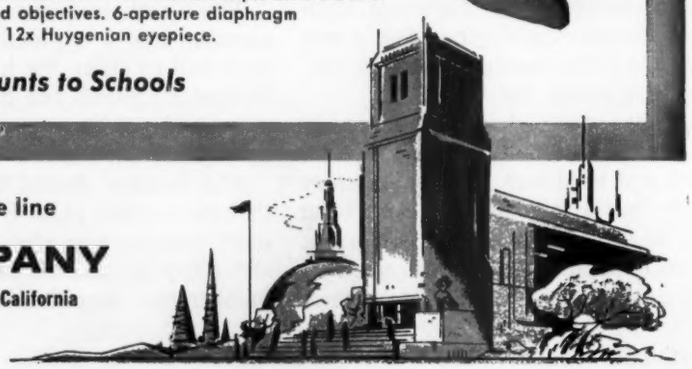

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Saturday Science. Scientists of Westinghouse Research Laboratories. Edited by Andrew Bluemle. 334p. $5.95. E. P. Dutton and Company, Inc., 300 Fourth Ave., New York 10, N. Y. 1960.

Occasionally a book combines science subject matter of importance and interest with a style which makes it readable and difficult to put aside. Such a book is *Saturday Science,* an outgrowth of the science program presented on Saturdays by the scientists of Westinghouse Research Laboratories for high school students of the Pittsburgh area. Science teachers who read the book will wish their classes could have been in Pittsburgh on these Saturday mornings.

The reader will be reminded of *Atoms in Action* by G. R. Harrison and of articles in the *Scientific American,* but comparisons do not tell the story. Although the chapters cover different areas of science, they form an integrated story and take one to the edge of the unknown. Each scientist is introduced by the editor in a personal manner, and then the scientist-author discusses the background of his work, what has been accomplished, and the direction of new research in his field.

The book is divided into two parts: "Principles" and "Techniques." The "Principles" section concerns those daily observations by humans that have become, or are becoming, physical laws. Chapters dealing with this phase of science are entitled: Light, Electrons and Crystals; Atomic Collision and Gas Discharge; Atomic Nuclei and Radioactivity; Low Temperature Phenomena; The Chemistry of Solids; The Physics of Metals; Microstructure and Heat Treatment of Metals; The Invisible Armor—Surface Films on Metals; and Propulsion. The "Techniques" section of the book treats of methods and machinery used by modern scientists in the study of traditional principles and discovery of new ones. Chapters covering this phase of science are entitled: Mathematics, Experimental Science, and an Apple Pie; Inhuman Arithmetic; Maxima and Minima in Physical Processes; Modern Analytical Methods; and The Interdisciplinary Nature of Science.

The individual personal style in which the authors have approached the material is not indicated in the chapter titles, which do not do justice to the content. It is a book that the teacher or his students will have to read carefully, like a textbook, for the science content is up to date and challenging. But it is more than this; the teacher will use it for his own knowledge, for outside reading assignments, and for direct quotations from the book in explaining some of the ideas to his own classes. And it is still more, for there is a suspense about the writing that leads the reader from page to page to see where this great exploration of our physical world is going to lead. In this process he is introduced to gifted thinkers of our time solving some complicated questions.

The style of the writers presents words in an easy flow of descriptive language. Excellence is achieved in their analogies; and clarity is gained by explaining complicated ideas not only with words, but also with well-presented illustrations. Many of these authors have been teachers and thus understand the value of communicating ideas clearly. An added bonus for the teacher will be the discovery of some new demonstrations of complicated physical concepts. The authors have used excellent methods to present their ideas, and the teacher will be able to adapt many of these to his own classroom.

A teacher will appreciate the book for its up-to-date material, and he will read it also for the method by which ideas are presented. He will want his students to read it for the information and for the inspiration they would receive from this association with scientists. It is a book that every science teacher will want for school and personal library and classroom use.

ALFRED B. BUTLER
Washington State University
Pullman, Washington

The Meaning of Wilderness to Science. Edited by David Brower. 130p. $5.75. Sierra Club, Mills Tower, San Francisco 4, Calif. 1960.

Much has been written about the use of natural areas for preserves. Describing how natural areas may be used as science laboratories, this book gives a collection of papers presented by distinguished scientists at the 1959 Sixth Biennial Wilderness Conference. Included also are edited and selected comments concerning the papers given by conference participants. Chapter headings indicate the nature of the content: Plants and Animals in Natural Communities, Ecological Islands as Natural Laboratories, Ecological Systems and Water Resources, The Outlook for Conservation in Alaska, Science and the Wilderness, Population Pressure and Natural Resources, Wilderness, Science, and Human Ecology. Some beautiful photographs of Alaska and its wildlife are included. A chapter deals with recommendations by the Conference for continued support of so-called wilderness legislation. These recommendations might well be read and discussed by many lay groups.

This is a book which is recommended reading for any science teacher who is conservation-minded or who needs more information so that he may become better acquainted with the philosophy of preservation of natural areas. It is thought provoking and might well be read not only by the nature enthusiast but also by a large number of the American citizens who wish to be better informed concerning one of their last untouched resources—the wilderness.

The content of this book adds another dimension to the argument for preservation of natural areas. It speaks for the scientist's approach to the study of wilderness areas. This, it seems to the reviewer, adds a strong supporting voice to the group who wishes to preserve natural areas for their aesthetic value.

H. SEYMOUR FOWLER
Pennsylvania State University
University Park, Pennsylvania

Land, Wood and Water. Robert S. Kerr. 380p. $4.95. Fleet Publishing Corporation, 230 Park Ave., New York 17, N. Y. 1960.

This important book, by the senior U. S. Senator from Oklahoma, derives strength from the life-long concern of its author with problems of conservation. His parents were part of the mass migration that settled the Indian Territory of Oklahoma. Sam Kerr, his father, often told him, "Where a man would make a home, he must have three things: land, wood, and water; good land where his crops will grow; wood for his cabin, fences, and fireplace; and water for his family and stock."

The author witnessed the tragedies of the dust bowl in the 1930's and, as governor, was responsible for administration of relief during the flooding of the Arkansas River in 1943. He carried his interests in conservation to a national level when he was elected to the United States Senate in 1948 on the slogan of "Land, Wood, and Water." Today, as chairman of the Select Senate Committee on National Water Resources, he is more deeply concerned than ever with developing public concern for wise handling of America's natural resources.

Early sections of *Land, Wood and Water* deal with the origins of our planet and its resources and with the social and economic backgrounds of some of our major resource-use problems.

Another section outlines the history of conservation efforts. It describes the contributions of Wesley Powell, who explored the Colorado River; of George H. Maxwell, California, crusader for effective irrigation bills; of Governor Gifford Pinchot of Pennsylvania; of President Theodore Roosevelt;

and of George W. Norris of the Tennessee Valley Authority.

A final section of the book outlines the "Kerr Plan" for a cooperative study by all government agencies concerned with the water supply. The purpose of the study is to determine a national water policy. The bipartisan Senate Committee directing the study is to report its recommendations for legislative action by January 1961. These recommendations, based on considerations of the nation's needs for the duration of the cold war and thereafter, should increase the interest of Congress and the American people in problems which are above partisan level.

MARGARET J. MCKIBBEN
Assistant Executive Secretary, NSTA

John Hay Fellows Program—Fellowships in the Humanities

Seventy-five John Hay Fellowships for 1961-62 will be awarded to senior high school teachers for advanced study at The University of California (Berkeley), The University of Chicago, Columbia University, Harvard University, Northwestern University, or Yale University. Applications should be filed by December 1. Awards will be equal to school salaries during the fellowship year. Address inquiries to: Dr. Charles R. Keller, Director, John Hay Fellows Program, 9 Rockefeller Plaza, New York 20, N. Y.

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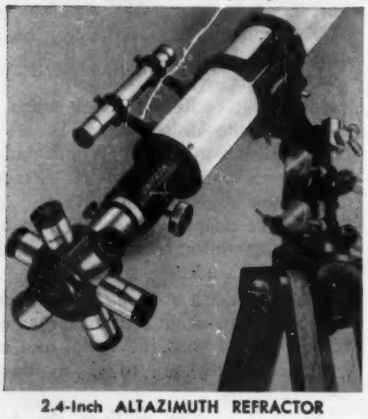

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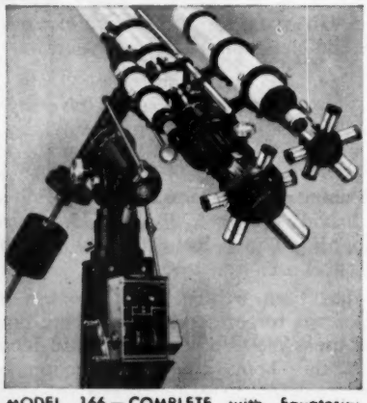

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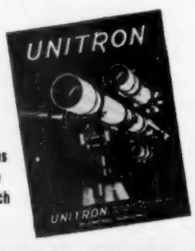

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AAAS Meeting

The annual joint meeting of NSTA and other science teaching societies affiliated with the American Association for the Advancement of Science will be held in New York City at the Roosevelt Hotel, December 27-30. Hotel reservations for those planning to attend should be made by writing to the AAAS Housing Bureau, 90 East 42nd Street, New York 17, New York.

Details of the sessions of the teaching societies, as well as of scientific societies meeting with the AAAS, will be published in full in the AAAS General Program. No separate program for the science teaching groups will be printed.

The general theme of all NSTA sessions is "The New Science—A Teaching Challenge." The subjects of the five sessions planned in accordance with this theme are:

I. **The New Chemistry, December 28, 9:30 a.m.** Roosevelt Ballroom Foyer.
   Presiding: Rev. Lucien R. Donnelly, O.S.B., Delbarton School, Morristown, New Jersey.
   Speaker: Alfred B. Garrett, The Ohio State University, Columbus.

II. **The New Astronomy, December 28, 4:00 p.m.** Roosevelt Ballroom Foyer.
   Presiding: Ruth E. Cornell, Wilmington, Delaware Public Schools.
   Speaker: Wasley S. Krogdahl, University of Kentucky, Lexington.

III. **The New Planet Earth, December 29, 9:30 a.m.** Roosevelt Ballroom Foyer.
   Presiding: Harold E. Tannenbaum, State University College of Education, New Paltz, New York.
   Speaker: Hugh Odishaw, United States National Committee, International Geophysical Year, National Academy of Sciences-National Research Council, Washington, D. C.

IV. **New Weather Theories, December 29, 2:00 p.m.** Oval Room.
   Presiding: Robert J. Chinnis, University of Pennsylvania, Philadelphia.
   Speaker: Harry Wexler, United States Weather Bureau, Washington, D. C.

V. **Biology of the Mind, December 30, 9:30 a.m.** Roosevelt Ballroom Foyer.
   Presiding: Margaret J. McKibben, National Science Teachers Association, Washington, D. C.
   Speaker: Irwin J. Kopin, M.D., Surgeon, National Institute of Mental Health, Presbyterian Hospital, New York City.

At each of these sessions, the speaker will present the frontiers of his particular field of science. A panel of persons representing elementary and secondary schools will then discuss implementation of this material in classrooms, K-12.

An "NSTA Reports" session will be held in the library of the Roosevelt Hotel at 2:00 p.m., December 27. The three Standing Committees will report on their activities at this time.

Membership Renewal

Renewal notices have been sent to all NSTA members whose membership year ends in December 1960. Prompt attention to this matter will insure uninterrupted service from the national headquarters. Members who have enrolled since last January 1 are reminded that membership extends for one year from date of entry. Therefore, renewal notices will be sent to some members each month from now on. Renewals and advice on any changes of address should be sent to headquarters without delay.

Teaching Aids Symposium

NSTA members and staff representatives cooperated with the Better Light Better Sight Bureau in evaluating teaching aids which they produced for general science teachers and students. The symposium, held at NSTA Headquarters on July 14-15, 1960, included a review of the objectives and printed materials of the teaching aids program. Participants included Philip M. Alden and Edward A. Campbell of the Better Light Better Sight Bureau, New York City. NSTA members who attended were Margaret K. Noble, Benning Elementary School, Washington, D. C.; Glenn E. Warneking, Wheaton High School, Wheaton, Maryland; Jerrold W. Maben, Michigan State University, East Lansing; Hugh Allen, Jr., Montclair State College, Upper Montclair, New Jersey; Harold Spielman, The City College, New York City; Christopher Vagts, ESSO Standard Oil

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TEACHING AIDS SYMPOSIUM—(Seated, l. to r.) Hugh Allen, Jr., Montclair State College, Upper Montclair, New Jersey; Alan Mandell, Norfolk County Public Schools, Norfolk, Virginia; John W. Renner, Associate Executive Secretary, NSTA; and Margaret K. Noble, Benning Elementary School, Washington, D. C. (Standing, l. to r.) Harold Spielman, The City College, New York City; Edward A. Campbell Better Light Better Sight Bureau, New York City; Philip M. Alden, Better Light Better Sight Bureau, New York City; Christopher Vagts, ESSO Standard Oil Company, New York City; Alexander Costea, Arlington County Public Schools, Arlington, Virginia; George A. Crosby, Business Manager, NSTA; Jerrold W. Maben, Michigan State University, East Lansing; and Glenn E. Warneking, Wheaton High School, Wheaton, Maryland.

Company, New York City; Alexander Costea, Arlington County Public Schools, Arlington, Virginia; and Alan Mandell, Norfolk County Public Schools, Norfolk, Virginia. Representatives of the NSTA headquarters staff participating in the conference were John W. Renner and George A. Crosby.

This NSTA service to business-industry provided another opportunity for educators and representatives of special groups to cooperate in carrying out a common objective—the improvement of science education in America.

Financial Contributions

A growing number of business-industry organizations and other groups are providing financial assistance for various NSTA projects and activities other than the Future Scientists of America program. Henceforth the listing of all these organizations will be given on this page, rather than under FSA Activities. Through September 19, 1960, these contributions total approximately $85,000. The expression of faith and confidence in NSTA which these dollar contributions represent is greatly appreciated.

Contributions since the last previous listing (February 1960 *TST*) are as follows:

Allied Chemical Corporation
American Can Company
American Society for Metals
Ampex Corporation
Armco Steel Corporation
The Atlantic Refining Company
Champion Spark Plug Company
Chrysler Corporation
Ciba Pharmaceutical Products, Inc.
The Dow Chemical Company
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Student Marketing Institute, Inc.
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Convention, 1961

First a reminder, then some current information on convention details.

The dates are March 24 through March 29, with the Supervisors' Section opening the show on the 24th and AETS ringing down the curtain on the 29th. The place is the Sherman Hotel, Chicago, Illinois. Watch for the special convention insert in next month's issue of *TST*. Do not delay making hotel reservations and sending in your advance registration.

Now for a first announcement of convention participants. The first general session will be at 9:00 a.m. on Saturday, March 25. "Recent Advances in the Physical Sciences" will be reviewed by Henry O. Eyring of the University of Utah, followed by James F. Crow of the University of Wisconsin, who will discuss "Recent Advances in the Biological Sciences."

That same evening at 8:00 p.m., the emphasis will be on activities in science and science education at the international level. Hugh Odishaw, executive director of IGY, and Abraham Raskin, director of NSTA's 1960 European Science Study Tour, will share the platform. There will be a showing of Kodachromes of the tour and several IGY films.

At general sessions Sunday afternoon and Sunday evening, two speakers will coordinate their discussion on "The Fundamental Nature of the Scientific Endeavor" and "The Nature of the Educational Endeavor in a Scientific Age." The first of these speakers will be Paul E. Klopsteg, chairman of the Board of AAAS, and the evening speaker will be Joseph J. Schwab, professor of science and education at The University of Chicago.

Nobel Laureate Glenn T. Seaborg, chancellor of the University of California, will be the principal speaker at the annual banquet, scheduled for Monday evening, March 27. His subject will be "The Teacher as Agent in the Educational Enterprise."

At the closing general session on Tuesday morning, March 28, James E. Russell, Secretary of the NEA Educational Policies Commission, will give an address on "Education for Our Democratic Enterprise."

The supporting cast of participants in panels, symposia, Here's-How-I-Do-Its, and other program items will number more than 200 persons.

And, of course, there will be the annual Exposition of Science Teaching Materials. This is by far the best opportunity of the year for those in the business of teaching science to see and examine the latest books, laboratory equipment, audio-visual materials, and other aids. The Association is glad to include these displays as part of the professional advancement services of the convention. More than 100 exhibitors will show their materials and have representatives on hand to explain and answer questions.

We know you will want to participate with the 2000 or more members and friends of NSTA who are planning to attend. Be there, share, see, and explore the advantages which your NSTA membership provides.

SCIENCE PROJECTS

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General Science

Biology Projects—McAvoy et al..... $3.75
Reprinted, 1959. Cloth Bound

Chemistry Projects—Chiddix 3.75
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General Science Projects—Bailey and Chiddix..... 3.50
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SCIENCE PUBLICATIONS

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The First Fifty Chapters

The title of inaugural chapters was bestowed upon the first fifty applicants to be enrolled in the Future Scientists of America program, the new youth organization of NSTA, during the festive and memorable week of October 15-23. The recognition of the first fifty chapters in preference to the usually accepted first chapter was due to the explosive national interest expressed in the youth program from all areas of the nation. In the majority of the presentations, a representative of NSTA was on hand to take part in the ceremonies by presenting the FSA charter to the school sponsor.

At the same time that FSA chapters were being inaugurated from border to border and coast to coast, another important facet of the program was taking place at the University of Iowa. An inaugural chapter charter was presented to the renowned physicist Dr. James A. Van Allen. This charter was accepted by Dr. Van Allen for the University of Iowa Laboratory High School and was presented to Dr. Robert E. Yager, the head of the school's science department. The other schools included in this inauguration ceremony for FSA, along with their sponsors and the approximate number of student participants, are listed below in alphabetical order by state. Those represented include twenty-seven states and the District of Columbia.

Walker County High School
Jasper, Ala.
Walter E. Nicholson (40 students)

Arkansas High School
Texarkana, Ark.
Millard I. Formby, Jr. (100 students)

Mena High School
Mena, Ark.
Aileen L. McWilliam (35 students)

Chaffey High School
Ontario, Calif.
John T. Tinson (200 students)

Menlo-Atherton High School
Atherton, Calif.
Harry K. Wong (100 students)

Branson High School
Branson, Colo.
Leonard H. Pratt (12 students)

Carr Consolidated School
Carr, Colo.
Robert W. Ruchensky (18 students)

Sinclair Junior High School
Englewood, Colo.
Alan R. Wenger (40 students)

Academy of Notre Dame
Washington, D. C.
Sister Anna Richard, S.N.D.
(50 students)

Manatee High School
Bradenton, Fla.
Philip V. Doyle (35 students)

St. Johns Country Day School
Orange Park, Fla.
Laura A. Wiesenfeld (75 students)

Marshall Community High School
Marshall, Ill.
Frank Floski (60 students)

Notre Dame High School
Chicago, Ill.
Sister Cecilia Louise, S.N.D.
(400 students)

University of Iowa Laboratory High School
Iowa City, Iowa
Robert E. Yager (25 students)

United Community School
Boone, Iowa
Kenneth E. Frazier (40 students)

Harper High School
Harper, Kans.
Chester J. Shepherd (18 students)

Sacred Heart Academy
Louisville, Ky.
Mary J. Herp (50 students)

De La Salle Juniorate School
Lafayette, La.
Brother C. Lawrence, F.S.C.
(34 students)

Erath High School
Erath, La.
Numa J. Broussard (50 students)

St. John High School
Jackson, Mich.
Sister Marie Aimee, I.H.M.
(100 students)

McKinley High School
Le Center, Minn.
Margaret L. Totusek (10 students)

Minnetonka High School
Excelsior, Minn.
Martin L. Thames (15 students)

Hallock High School
Hallock, Minn.
David R. Halgren (20 students)

Chaffe High School
Chaffee, Mo.
Charles A. Goddard (75 students)

St. Francis Borgia High School
Washington, Mo.
Sister M. Hermias Mennemeyer,
S.S.N.D. (128 students)

St. Agnes Academy
Alliance, Nebr.
Sister Mary Emilia (40 students)

Superior High School
Superior, Nebr.
Glen E. Dirreen (25 students)

St. Mary High School
Paterson, N. J.
Sister Michael Bernard, O.P.
(45 students)

Aquinas Institute
Rochester, N.Y.
Rev. James F. Cross (25 students)

Archbishop Stepinac High School
White Plains, N. Y.
Brother Norbert, C.F.X. (150 students)

Baker-Victory High School
Lackawanna, N. Y.
Rev. Aloysius B. Balcerak (75 students)

Bishop McDonnell Memorial High School
Brooklyn, N. Y.
Sister M. Thomas Aquin, O.P.
(50 students)

The Bronx High School of Science
New York City
Zachariah Subarsky (100 students)

Bandys High School
Catawba, N. C.
Everette M. Caldwell (85 students)

Celeste Henkel High School
Statesville, N. C.
Kathryn R. Arey (20 students)

Scranton Public School
Scranton, N. D.
Andrew J. Brown (20 students)

Sulpher High School
Sulpher, Okla.
Buford A. Merritt (30 students)

Central Catholic High School
Canton, Ohio
Brother David Arnold, F.S.C.
(20 students)

Sacred Heart High School
Pittsburgh, Pa.
Sister M. Alexine, I.H.M. (35 students)

Vincentian High School
Pittsburgh, Pa.
Sister M. Mildred, V.S.C. (40 students)

Central High School
Cookeville, Tenn.
Bertie B. Buck (25 students)

Avinger High School
Avinger, Texas
Royse C. Shaddix (60 students)

Keystone School
San Antonio, Texas
Edwin W. Eargle (50 students)

Lake Worth High School
Fort Worth, Texas
J. C. Kinchen (45 students)

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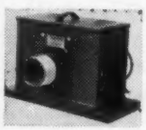

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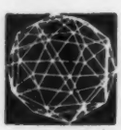

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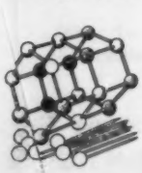

This low-priced kit can be used to make many molecular and crystal models. Consists of 50 sponge rubber balls, 1 inch in diameter and 50 wooden sticks, 6" x ⅛" that can be cut to any desired length. Balls may be painted, after assembly, to standard molecular model colors. With this one kit, molecules with up to fifty atoms can be made. Several kits can be used to make up more complex models.

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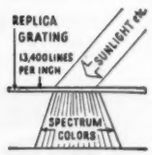

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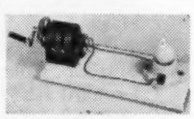

For classroom experiments, demonstrations. Simple, dramatic way to show how electrical circuit is set up and how energy produces electricity. Three-magnet generator comes mounted on 4" x 10" wooden base with standard lamp receptacle and 7½ watt bulb. Unloaded, unit produces 120 volts—or 60 volts across the 7½ watt bulb included. Each of the 3 steel magnets is 2" high, faces are ⅞" x ⅜". Generator is 4⅛" long x 3⅛" tall.

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CELL KIT

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FSAA Regional Chairmen

The eleven regional chairmen selected by NSTA for the 1960-61 Future Scientists of America Awards program are now assembling judges who will evaluate 6000 or more reports of student projects which will be entered in this competition. The work of the chairmen and their selected committees to judge and evaluate entries is an important and much appreciated task. Chairmen who have taken on the responsibility this year are as follows: Region I, Edgar N. Johnson, West Springfield High School, West Springfield, Massachusetts; Region II-A, Samuel W. Bloom, Benjamin Franklin High School, Rochester, New York; Region II-B, Rev. Lucien R. Donnelly, Delbarton School, Morristown, New Jersey; Region III, James W. Cole, Jr., University of Virginia, Charlottesville; Region IV, Annie Sue Brown, Atlanta Public Schools, Atlanta, Georgia; Region V-A, S. Alton Yarian, Emerson Junior High School, Lakewood, Ohio; Region V-B, William Powell, Edwardsville High School, Edwardsville, Illinois; Region VI, Robert E. Yager, University High School, University of Iowa, Iowa City; Region VII, Sam S. Blanc, Gove Junior High School, Denver, Colorado; Region VIII-A, John S. Hutchinson, Portland Public Schools, Portland, Oregon; and Region VIII-B, Harry K. Wong, Menlo-Atherton High School, Atherton, California.

The mailing of all entries for this year's FSAA program as much in advance of the *March 1, 1961* deadline as possible will assist these chairmen and their committees in their efforts to complete selections of winning projects in time for all student awards to be presented by June 1, 1961. (See page 46.)

FREE SCIENCE MATERIALS

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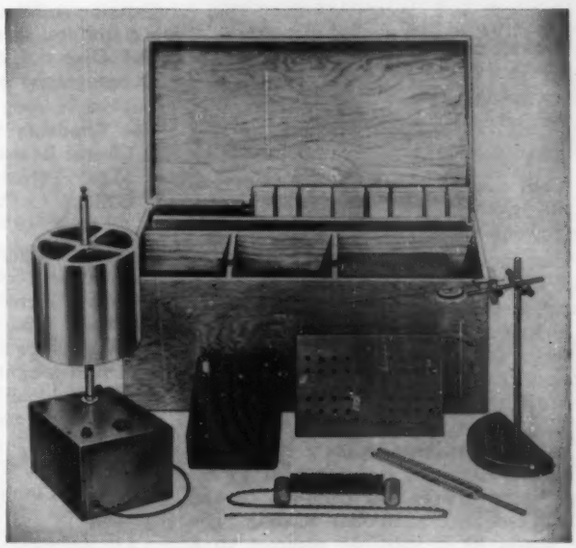
Special kits containing equipment and supplies other than those listed for the standard Kit #1000 can be made to order. In all cases, the cost will be a total of list prices. We invite you to send for our Catalog 1960-61 and new price list which contain our complete line of recording instruments and accessories, circulation and respiration equipment, electrical equipment, clamps, stands, rods and various animal accessories. Also available on request is a detailed data sheet listing the contents of the standard Kit #1000 plus a range of auxiliary equipment.

Harvard Apparatus Company, Inc., a non-profit organization, seeks to promote better science teaching through the manufacture of superior physiological apparatus made available at the lowest possible cost. All apparatus is of the highest quality and will give years of continuous service.



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SCIENCE TEACHING MATERIALS

Prepared by NSTA Teaching Materials Review Committee

Chairman: Dr. H. Seymour Fowler

The Pennsylvania State University, University Park, Pennsylvania

BOOK BRIEFS

Animal Growth and Development. Maurice Sussman. 114p. Paper $1.50, cloth $2.95. Prentice-Hall, Inc., Englewood Cliffs, N. J. 1960.

Another book in the Foundations of Biology Series. Excellent line drawings and photographs add meaning to the text material. Covers current concepts of cell physiology and genetics as indicated by the following chapter headings: What Is Development? The Life Cycle of a Single Cell, The Beginnings of Multicellular Organization, The Development of a Primitive Animal, Coelenterates, The Development of the Vertebrate Embryo, Cellular Differentiation, Cell Interactions During Growth and Morphogenesis, and Growth and Form. A list of selected readings is included. A useful volume for the high school biology teacher's reference library.

The Cell. Carl P. Swanson. 114p. Paper $1.50, cloth $2.95. Prentice-Hall, Inc., Englewood Cliffs, N. J. 1960.

A volume in the new Foundations of Biology Series. Chapter headings include: Cells in General, Structure of Cells, Mitosis, Meiosis, Cell in Reproduction—Animals, Cell in Reproduction—Plants, The Cell in Development, and The Cell in Death. Covers historical development of the understanding of the cell and its functions. Difficult topics such as reproduction in plants are described clearly and concisely. Accompanied by excellent line drawings and photographs and a list of selected additional reading. The book would be a valuable addition to a biology teacher's reference shelf and for use in advanced biology classes.

Animal Physiology. Knut Schmidt-Nielsen. 118p. Paper $1.50, cloth $2.95. Prentice-Hall Inc., Englewood Cliffs, N. J. 1960.

A third book in the Foundations of Biology Series. Contains frequent reference to the physiology of man as well as animals. Relationship of the animal to its environment is treated well. Many difficult and confusing topics such as osmosis, temperature regulation, and muscle action are described clearly and concisely. Chapter headings indicate the nature of the content: Food and Energy, Oxygen, Temperature, Water, Movements, Information, and Integration. A list of selected readings is included. Modern in its approach to the study of biology, this book should be on every biology teacher's reference shelf. Recommended also for better students in a second-year biology course.

The Biological Effects of Radiation—A Report to the Public. 20p. Free. National Academy of Sciences-National Research Council, 2101 Constitution Ave., N.W., Washington 25, D. C. 1960.

Up-to-date information for high school science teachers on the biology of radiation. Chapters are entitled Genetic Effects, Pathologic Effects, Meteorological Aspects, Agricultural and Food Supplies, Disposal and Dispersal of Radioactive Wastes, and Oceanography and Fisheries.

The Graduate School and the Decline of Liberal Education. Earl J. McGrath. 66p. $1.50. Bureau of Publications, Teachers College, Columbia University, New York 27, N. Y. 1959.

The strengthening of the graduate school in the twentieth century has been at the expense of liberal education. Several changes including what follows are recommended for the preparation of college teachers—improved programs for college teachers and other graduate students, broader graduate education, research projects, and apprenticeships.

Ice Age Coming? Leverett G. Richards. 128p. $3.25. John Day Company, Inc., 210 Madison Ave., New York 16, N. Y. 1960.

The author presents (1) a generalized description of the Pleistocene glaciation, (2) a description of glaciers of significance in the world today, and (3) various theories that attempt to explain glaciation in general, but never answers the question presented by the title. Glaring errors occur in the discussion of the Pleistocene. Contradictions within sentences and paragraphs occur occasionally. In general, theories are accepted as fact. Readable for upper elementary and junior high school students but not completely reliable or scientific. Well illustrated with excellent photographs. Also has some worthwhile discussions, especially regarding polar expeditions.

The Moon, Earth's Natural Satellite. Franklyn M. Branley. 114p. $3.50. Thomas Y. Crowell Company, 432 Fourth Ave., New York 16, N. Y. 1960.

Contains the usual conventional information about the moon with a special effort to clarify for the seventh (and higher) grades the concepts of gravitation, mass, density, liberation, and orbits. Author presents views by discussing, in the light of recent discoveries, what man will find on the moon when he gets there. Diagrams and charts are especially effective.

How to Make Fish Mounts. Edward C. Migdalski. 218p. $5.50. The Ronald Press Company, 15 East 26th St., New York 10, N. Y. 1960.

Contains detailed directions and many drawings and photographs to show the fisherman how to mount a trophy fish—cheaply and easily. Shows, through photographs, the whole gamut of trophies, field care of fishes, preparing molds, skin mounts, special trophies as head, tail, bill or jaws, and their painting and finishing. Describes how to collect, preserve, and organize for display an amateur or museum fish collection. The last chapter gives a fine list of materials and formulas, with directions on how to prepare and use them.

From Rocks to Rockets. Solveig Paulson Russell. 32p. $2.75. Rand McNally and Company, P.O. Box 7600, Chicago 80, Ill. 1960.

An interesting story of man's continuing search for faster and more efficient machines to help conquer his environment. Embraces anthropology and the science of simple tools from the caveman to the explorers of space. Written for the young reader. Illustrated.

In the Days of the Dinosaurs. Roy Chapman Andrews. 82p. $1.95. Random House Inc., 457 Madison Ave., New York 22, N. Y. 1959.

An "Easy-to-Read Book" by a well-known authority. This extremely interesting book includes many excellent illustrations and a map showing location of dinosaur remains. The reader feels as if he were accompanying the author on his field trips and living his experiences with him. Covers identification of dinosaurs and aids to pronunciation of names. For upper elementary use.

The Boys' Second Book of Radio and Electronics. Alfred Morgan. 276p. $3. Charles Scribner's Sons, 597 Fifth Ave., New York 17, N. Y. 1957.

An excellent book on a timely subject. It takes the novice from the construction of a simple crystal receiver to the construction and operation of a miniature home broadcasting station. Each construction is well illustrated with a schematic circuit diagram and a pictorial diagram. The theory is stated in a simple and clear form. No recent revision has been made, but this is an excellent source for current use.

So You Want to Be a Scientist. Alan E. Nourse. 182p. $3. Harper and Brothers, 49 East 33rd St., New York 16, N. Y. 1960.

Guidance or science counselors might well profit from this work. The author takes the reader through a discussion of what science is, how to prepare to enter it, and the qualifications and goals for scientific work. Contains a complete and revealing discussion of the different sciences and gives the reader an insight into science careers. Recommended for any high school science department.

Science Experiments for Every Boy and Girl. Louis J. Kleinman. 192p. $1. Hart Publishing Company, Inc., 74 Fifth Ave., New York 11, N. Y. 1960.

Contains instructions for simple experiments with air, heat, natural forces, electricity, water, light, sound, chemicals, the human body, and plants, utilizing typical materials found around the home. Each experiment is clearly explained in everyday language and has an accompanying illustration. For middle and upper elementary students.

Biology—The Science of Life. Addison E. Lee. 270p. $2. The Steck Company, 205 West Ninth St., Austin, Texas. 1958.

Each chapter in this work-text for high school biology includes a text discussion of a topic, demonstrations and experiments, workbook-type answer sheets, and lists of additional activities under a section entitled "Extra Things to Do." Contains numerous line drawings. Spiral bound. [No recent revision has been made, but this is an excellent source for current use.]

Modern General Science. Alan Humphreys. 256p. $2. The Steck Company, 205 West Ninth St., Austin, Texas. 1959.

A work-text for ninth-grade general science which combines the features of a textbook with a modified workbook. Each section of the book includes both selected text material and demonstrations and experiments. Ample space for recording answers to questions is provided. Illustrated with line drawings and black and white photographs. Topics from the physical and biological sciences well represented. Spiral bound.

Careers and Opportunities in Chemistry. Philip Pollack. 148p. $3.50. E. P. Dutton and Company, Inc., 300 Fourth Ave., New York 10, N. Y. 1960.

A very informative book for the high school student curious about the field of chemistry. The author takes the reader through a brief history of chemistry and the growth of the profession and discusses its different branches adequately. Of special interest to counselors and students is the chapter on qualifications and training. An appeal is also made for training women in chemistry.

How to Know and Predict the Weather. Robert Moore Fisher. 136p. 50¢. Signet Key Book, The New American Library of World Literature, Inc., 501 Madison Ave., New York 22, N. Y. 1960.

Written for the layman, this book is handy and readable. Contains interesting information about weather processes. Acquaints reader with the processes which make up the weather and shows the meaning of certain signs, comparing them with ancient weather proverbs. The author has an appealing style which makes the book easy to read. It should evoke an appreciation of the intricacy of the atmosphere and promote an understanding of the problems confronting meteorologists when they predict weather conditions.

Shots Without Guns. Sarah R. Riedman. 222p. $3.50. Rand McNally and Company, Box 7600, Chicago 80, Ill. 1960.

An interesting and exciting book for the high school student on the life of famous scientists who conquered infectious diseases. The story begins with Edward Jenner and continues to present-day scientists such as Salk. Clearly describes the adventures, hopes, and disappointments of these famous men. An asset to any high school library.

Problem Situations in Student Teaching. Gwynn A. Greene. 68p. $1.25. Bureau of Publications, Teachers College, Columbia University, New York 27, N. Y. 1959.

A series of 39 open-ended accounts of student-teaching experiences in elementary and secondary schools. The situations described should encourage exploration and thoughtful analysis of teaching problems.

Things to Do in Science and Conservation. Byron Ashbaugh and Muriel Beuschlein. 162p. $2.50. The Interstate Printers and Publishers, Inc., 19-27 North Jackson St., Danville, Ill. 1960.

Each of the eleven chapters represents a different, basic, natural, or man-developed resource. Principles of science are stressed throughout by means of suggested demonstrations and projects. The book contains materials appropriate for both elementary and secondary grades.

Man in the Making. Estelle Friedman. 192p. $2.95. G. P. Putnam's Sons, 210 Madison Ave., New York 16, N. Y. 1960.

Written for high school students, this book should awaken interest in young people relating to the science of anthropology. Author describes the discovery of the first remains of animals and the difficulty of researchers to convince the public that such forms actually existed millions of years ago.

Space Monkey. Olive Burt. 64p. $2.50. The John Day Company, 62 West 45th St., New York 36, N. Y. 1960.

Describes the events leading up to and following a successful space flight by a monkey. Much emphasis is placed on the special care given to such animals and the valuable information that is obtained from the flights. Recommended for upper elementary and junior high school.

The Wonder of Light. Hy Ruchlis. 154p. $2.95. Harper and Brothers, 492 33rd St., New York 16, N. Y. 1960.

The characteristic feature of this book is the explanation of the optical phenomena of everyday life through concepts that are introduced in simple and almost nontechnical language. Very well written. The illustrations have been chosen extraordinarily well. Useful for upper elementary and high school students, as well as the general reader.

Exploring Science Series. Teachers' Edition. Walter A. Thurber. Grade One, 160p. $2.32. Grade Two, 176p. $2.52. Grade Three, 200p. $2.68. Grade Four, 260p. $2.88. Grade Five, 360p. $2.92. Grade Six, 360p. $3.12. Allyn and Bacon, Inc., 150 Tremont St., Boston 11, Mass. 1960.

A series with a challenging approach to the science experiences of children in grades 1-6. Adequate information and excellent illustrations. Teachers' edition considers each unit from the standpoint of preparation, teaching procedures, summary, follow-up, possible learning, and includes a bibliography. This should give the young teacher, especially, confidence in undertaking the teaching of elementary science. A good science series for the elementary program.

Handbook for Space Travelers. Walter B. Hendrickson. 252p. $3.95. The Bobbs-Merrill Company, Inc., 1920 East 38th St., Indianapolis, Ind. 1960.

This book provides a useful source of information about space, space travel, and life on other planets. An important chapter treats of various instruments which scientists utilize to study physical and chemical aspects of outer space. Covers the history of rocketry and space technology. Lastly, con-

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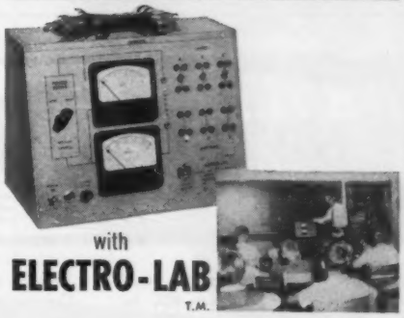

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ditions for life on the planets are described. Interesting book for junior and senior high school.

Medical Science and Space Travel. William A. Kinney. 150p. $3.95. Franklin Watts, Inc., 575 Lexington Ave., New York 22, N. Y. 1959.

A story of the problems and research involved in space exploration. Includes sections on problems of selecting space men, developing space craft, experimenting with space flight, and discovering information about the nature of outer space. Contains a radiation glossary. Well illustrated. Recommended for upper elementary and junior high school.

The Rockets' Red Glare. Mortimer W. Lawrence. 122p. $2.75. Coward-McCann, Inc., 210 Madison Ave., New York 16, N. Y. 1960.

An excellent portrayal of the conquest of space. Content grows from fact. Well written for grades 6-9. Includes historical background of rocketry. Good photography. Contains glossary.

The Story of Butterflies and Other Insects. Peter Farb. 126p. $2.95. Harvey House, Publishers, Irvington-on-Hudson, N. Y. 1959.

An illuminating treatment of the more common insects seen in a child's world. Sketches and colored plates of butterflies and moths will assist the intermediate-grade reader in his quest for information. Describes some of the lesser-known insect oddities and contains a guide for identification and aids for insect collection and study.

Laboratories in the Classroom. Science Materials Center, Inc. 96p. Free. 59 Fourth Ave., New York 3, N. Y. 1960.

The book represents an excellent thumbnail report of the problems, programs, and possible future trends of science education in the United States. The incorporation of articles written by twenty-seven of the leading science educators in the U. S. into one book is a formidable task in itself. But in an even greater sense, the differences in style, philosophy, and future expectations expressed by these authors are both provocative and informative. As the reader might well anticipate, opinions voiced by so large a group on so broad a topic will show considerable variation. There is one point of emphasis, however, common to all—the advancement of science education.

Science for Better Living Series. Paul F. Brandwein, Leland G. Hollingworth, Alfred D. Beck, Anna E. Burgess, and Violet Strahler. **You and Your World** (7th grade). 474p. $3.68. **You and Your Resources** (8th grade). 536p. $3.96. **You and Science** (9th grade). 702p. $4.84. Harcourt, Brace and Company, 750 Third Ave., New York 17, N. Y. 1960.

A series of junior high texts, revising 1955-56 editions. New material added to include up-to-date concepts which are accurate and detailed. Suitable vocabulary for the various grade levels. Teacher's manual includes teaching suggestions, graded to student levels of ability, and lists of references and source materials. Each text has extensive glossary and index. An adequate series, well written and well illustrated.

Human Development. Phyllis C. Martin and Elizabeth Lee Vincent. 542p. $6.50. The Ronald Press Company, 15 East 26th St., New York 10, N. Y. 1960.

Although designed as a college-level introduction to human biology for general education, this totally new text will also be useful in advanced biology courses in high school. The usual anatomical and physiological aspects of human biology have been supplemented with embryological and psychological material. Readable and interesting. Well illustrated with original drawings.

Kettering, Master Inventor. Sigmund A. Lavine. 174p. $3. Dodd, Mead, and Company, 432 Fourth Ave., New York 16, N. Y. 1960.

An interesting biography of Charles Franklin Kettering, inventor, scientist, and engineer. Emphasizes the importance of characteristics needed for success in invention. Good general reading material for junior and senior high school students.

The Sense of Smell. Roy Bedichek. 264p. $3.95. Doubleday and Company, Inc., 575 Madison Ave., New York 22, N. Y. 1960.

An intriguing presentation of the olfactory sense in animals and man. The naturalist

BPOMOΣ

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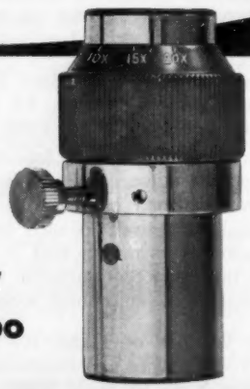

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The Wonderful Story of You. Benjamin C. and Sidonie M. Gruenberg. 182p. $2.95. Garden City Books, Garden City, N. Y. 1960.

A lucid protrayal of the development and functions of the human body from reproduction to adulthood. Describes in simplified fashion the complexities of the human being and relates physiology to personality development and problems of growing up. A helpful guide for both parents and youngsters in understanding human growth and behavior. Well illustrated.

The Story of Planets, Space and Stars. Gaylord Johnson. 154p. $2.95. Harvey House, Publishers, Irvington-on-Hudson, N. Y. 1959.

This brief but comprehensive work on astronomy, beautifully illustrated with many telescopic photographs, should whet the appetite of students in fifth through eighth grades for further study. Star maps, charts, suggested activities, and a good index make this book adaptable as a reference for children and teachers. Traces of history are interestingly woven into the text.

The Magic of Rubber. E. Joseph Dreany. 92p. $2.75. G. P. Putnam's Sons, 210 Madison Ave., New York 16, N. Y. 1960.

Graphically illustrates the story of rubber from the time it drips out of a tree until the finished product is put into use. Current developments in synthetic rubber research are described. The student is introduced to some of the pioneers in the field of rubber such as Charles Goodyear, Michael Faraday, and Granville Williams. Written in a clear understandable way for ages 8-12.

PROFESSIONAL READING

"The Egghead Millionaires." *Fortune,* 62:172. September 1960. Featuring a "new cold-war breed, scientists turned manufacturers," this article is of general interest to all science teachers. It describes how some of the top twenty young scientists formed their own companies, why so many are located near universities, and what they think about their meteoric rise in the business world.

"Accurate Measurement of Time." By Louis Essen. *Physics Today,* 13:26. July 1960. Science is in need of clocks which will measure frequencies more accurately than pendulum timepieces. In the measurement of time today, science must be in step with the atom rather than the earth. The author cites the atomic clock and the quartz clock as examples of accurate measurements and describes their operation.

"The Next Hundred Years' Energy Demand and Sources of Supply." By Lewis G. Weeks. *Geotimes,* 5:18. July-August 1960. "Whence will come our energy in the year 2059?" This is the question the article sets out to answer. Such factors as population growth and its effect upon the world's energy supply, sources of energy supply, and oil production methods are discussed.

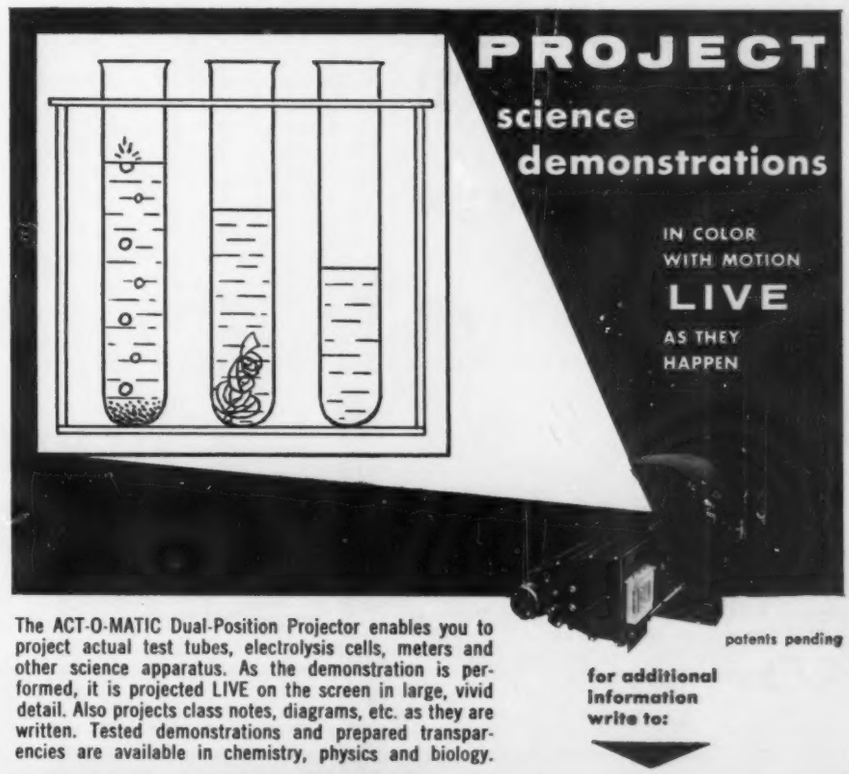
"Evaluation and Follow-up Study of a Summer Science and Mathematics Program for Talented Secondary School Students." A most informative and detailed report of 78 pages, issued by the Harvard University Graduate School of Education, Cambridge, Mass., June 30, 1960. Included is an explanation of research methods, identification of the instruments used in pre- and post-testing of program entrants, a critical analysis, and recommendations for improvement which were gleaned from the study.

This report is available in the depository libraries of the Library of Congress, Washington 25, D. C., and should be of value to all teachers who desire the latest evaluative information concerning summer science and mathematics programs for talented secondary school students.

"Vertical-Takeoff Aircraft." By John P. Campbell. *Scientific American,* 203:41. August 1960. A well-written pictorial and graphic review of the history, current research, and future plans of the Vertical-Takeoff Aircraft. Information contained in the article is of considerable value to the secondary school teacher of physics.

"New NSF Programs Aid Academic Research." *Chemical and Engineering News,* 38:46. August 8, 1960. An informative article about the dispersement of funds to colleges by the National Science Foundation. An interesting feature is that these colleges must have programs leading to the Doctoral Degree before NSF funds can be made available.

"Science in the News." *Science,* 132:337. August 5, 1960. The science and education pro's and con's of both presidential aspirants are treated in an objective manner in this well-written, informative article describing their platforms and personalities. The political articulation of the writer is evidenced by the depth of understanding he exhibits concerning the staff selection of each candidate. Further, the effect of this selection on the advancement of science and education is discussed at length. The article is recommended to the science teacher for current information on science, education, and politics.



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The Earth: Resources in the Crust. Designed for upper elementary and junior high school, the film discusses materials found in the crust of the earth—iron, aluminum, fuel (coal, oil, and natural gas), uranium, limestone, clay, sand, sulfur, and salt. Iron mining and smelting are covered as well as the making of alloys. 11 min. Color $110, B&W $60. 1960. Coronet Instructional Films, Coronet Building, Chicago 1, Ill.

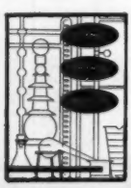
The Earth: Its Oceans. This film introduces one of man's untapped resources, the ocean. Covers a description of oceanography as a science, the topography of the bottom of the sea, and materials and living things in the sea. Man's early attempts to learn more about the sea are portrayed. Describes ocean currents, the techniques for studying these currents, and their influence on climate. The relationship between weather and wave motion is also included. Recommended for junior high general science or earth science, and some portions which treat the life of the oceans may be appropriate for high school biology. 13½ min. Color $137.50, B&W $75. 1960. Coronet Instructional Films, Coronet Building, Chicago 1, Ill.

The Excretory System. Film shows blood and tissue fluids, the anatomy of the excretory system, and how the proper functioning of the kidneys is necessary for good health. Recommended for junior and senior high school biology classes as well as for health studies. 13 min. Color $137.50, B&W $75. 1960. Coronet Instructional Films, Coronet Building, Chicago 1, Ill.

Let's Catch Reptiles. Illustrates characteristics of the class Reptilia. Three youngsters take a field trip to study reptiles. They find various lizards, a turtle, and a kingsnake. Harmless methods of capturing the reptiles are shown, with emphasis on returning the animals to their natural habitat. Film encourages careful study of reptiles, stresses kindness to animals, and would be useful in helping to overcome some of the unfounded bias against reptiles. Recommended for science classes in grades 5-8. 11 min. Color $110. 1959. Bailey Films, Inc., 6509 De Longpre Ave., Hollywood 28, Calif.

I Choose Chemistry. A science guidance film which will encourage students to elect science courses and science careers. Depicts the story of a boy's interest in chemistry from his introduction to the subject through a chemistry set to his graduation from college. Emphasizes the importance of understanding mathematics if a career in chemistry is chosen. Would be appropriate for junior high school as a guidance film, but may lack some sophistication for use above the tenth grade. 15 min. Color $150, B&W $75. 1959. Bailey Films Inc., 6509 De Longpre Ave., Hollywood 28, Calif.

Understanding Matter and Energy. Woven into a boy's conversation with the narrator is a thorough demonstration of the physical properties of matter in its solid, liquid, and gaseous state. The action of these properties is shown through animation. Film portrays the concept of the transformation of matter to energy for the production of heat, light, and electricity and compares the sun as the source of energy to the potentials of the atomic structure of matter. Recommended for junior high. 18 min. Color $185. 1960. International Film Bureau, Inc., 57 East Jackson Blvd., Chicago 4, Ill.



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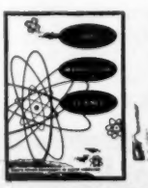
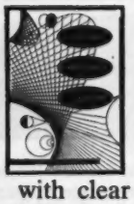
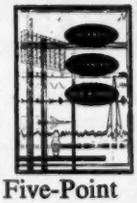


ELEMENTARY GRADES





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Universe. In a technique which combines actual photography with models, film presents a study of the moon, planets, comets, sun, and sunspots. Includes excellent photography of the actual working parts of a telescope and its use by astronomers. Shows method of locating stars and manner in which telescope follows their movements. Recommended for general science or earth science. 29 min. B&W $130. 1960. National Film Board of Canada, 680 Fifth Ave., New York 19, N. Y.

The Story of Soil. Recommended for upper elementary and junior high school. Content of the film includes the story of the development of soil, how man has caused destruction of the soil, and measures taken to prevent soil erosion such as terracing, rotating crops, foresting, and contouring. Particular emphasis is placed upon harmony between man, plants, and animals for proper soil maintenance. 11 min. Color $110, B&W $60. 1960. Coronet Instructional Films, Coronet Building, Chicago 1, Ill.

Acids, Bases and Salts. This film is recommended for the senior high school level. The content centers around theories of ionization and the properties, preparation, and uses of acids, bases, and salts. Theory is up to date. 21 min. Color $220, B&W $120. 1960. Coronet Instructional Films, Coronet Building, Chicago 1, Ill.

What Are Things Made Of? A short introduction to chemistry is presented, designed for use in upper elementary and junior high school. Solids, liquids, and gases are discussed as well as atoms, molecules, compounds, and mixtures. Physical and chemical changes are introduced to give an understanding of changes in matter. 11 min. Color $110, B&W $60. 1960. Coronet Instructional Films, Coronet Building, Chicago 1, Ill.

Conserving Our Forests Today. Film shows how forests supply us with wood, various kinds of paper, cellulose, synthetic textiles, and motion-picture film. Illustrates grazing on forest lands in the West, forest protection of watersheds, and utilization of forests in the Pacific Northwest and the South. Compares rate of growth of a human to that of a Southern forest tree. Methods of conserving our forest resources are also discussed. One of the best features of the film is its portrayal of modern forest fire fighting methods. Recommended for junior high school science or biology classes. 11 min. Color $110, B&W $60. 1960. Coronet Instructional Films, Coronet Building, Chicago 1, Ill.

The Earth: Changes in Its Surface. The film discusses such internal and external forces that change the earth's surface as synclines, anticlines, volcanoes, weathering, glaciation, and others. Recommended for upper elementary and junior high school science classes. 11 min. Color $110, B&W $60. 1960. Coronet Instructional Films, Coronet Building, Chicago 1, Ill.

The Earth: Its Structure. This film portrays the origin of the solar system and the earth. It illustrates how the molten material cooled, forming the major surface features of the earth. One of the film's best features is the portrayal of methods for discovering the nature of the crust. Other topics include the nature of the earth's interior and the formation of igneous, sedimentary, and metamorphic rock. Recommended for junior high school general science or earth science. 11 min. Color $110, B&W $60.

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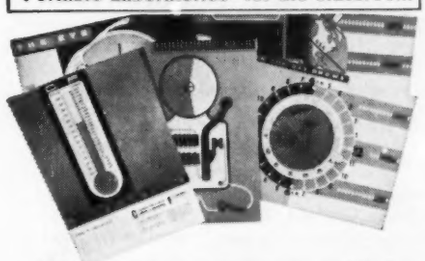

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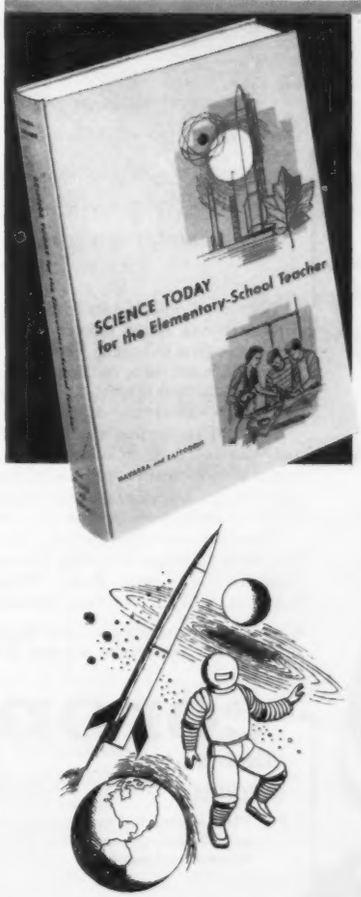

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Reaching Into Space. Presents a chronological overview of man's attempt to free himself from the confines of travel limited to earth. A historical approach follows: da Vinci's design of a flying machine, the use of rockets by the ancient Chinese, the first successful balloon flight by the Chinese, the first powered air flight by the Wright Brothers, and exploration by rocket-launched satellites. Principles of rocket flight including Newton's Third Law are covered. Recent space exploration is protrayed by animation and actual photography. Covers the work of the astronauts as well as photographs of the earth taken on rocket flights. Appropriate for grades 5-9. 14 min. Color $150. 1960. International Film Bureau, Inc., 57 East Jackson Blvd., Chicago 4, Ill.

Birds: How We Identify Them. This film for the young beginner in ornithology illustrates how three characteristics—appearance, actions, and sounds—are used to assist in identification of birds. Two young "birdists" take a field trip and learn to recognize a robin, bluebird, purple martin, wren, goldfinch, hummingbird, hawk, crow, and meadowlark by recalling the three characteristics with the introduction of each new species. The film would be stronger if the sounds and motions of the birds were synchronized. Should be useful through fifth grade as an indoor introduction to birding. 11 min. Color $110. 1960. Coronet Instructional Films, Coronet Building, Chicago 1, Ill.

Eggs to Chickens. This film for elementary school science students illustrates simply the life cycle of the chicken, showing anatomy of the hen, development of the embryo within the egg, and the chick emerging from the shell. The story involves a visit of two youngsters to a chicken ranch. The rooster-hen-chick relationship is explained through a discussion of fertile and nonfertile eggs. The film does not portray natural incubation but instead shows the use of an artificial incubator. Film recommended for grades 4-7. 10 min. Color $110, B&W $60. 1959. Bailey Films, Inc., 6509 De Longpre Ave., Hollywood 28, Calif.

The Grass-Blade Jungle. This film for elementary grades is designed to help children study and identify insects and other arthropods. Portrays the variety of life found on a lawn, and shows representatives of the different classifications of arthropods, their ecology, and their relationships. Anatomical features useful in identification are illustrated. 11 min. Color $120. 1959. Bailey Films, Inc., 6509 De Longpre Ave., Hollywood 28, Calif.

Language of Algebra. The film combines animation with photography to illustrate the substitution of algebraic symbols for actual objects from which the symbols developed historically. Describes the solving and evaluation of formulas, the meaning of subscripts, and sets of conditions for solutions. Includes the use of modern computing machines. Film may be helpful to junior and senior high school teachers in reviewing the use of simple algebra in science problems. 16 min. Color $165. 1960. International Film Bureau, Inc., 57 East Jackson Blvd., Chicago 4, Ill.

Conserving Our Soil Today. This is a good conservation film showing the importance of soil and demonstrating how it directly affects our lives. One of the films' strong points is the presentation of some of the newly developed soil conservation techniques. Illustrates products from the soil, soil loss through erosion, soil formation, and the development of humus. Emphasizes the importance of gathering information concerning soils through research and the technical assistance available to land owners through the United States Soil Conservation Service. Shows how recommended soil-conservation measures may be applied to the land. Film is appropriate for junior high general science and biology classes. 11 min. Color $110, B&W $60. 1960. Coronet Instructional Films, Coronet Building, Chicago 1, Ill.

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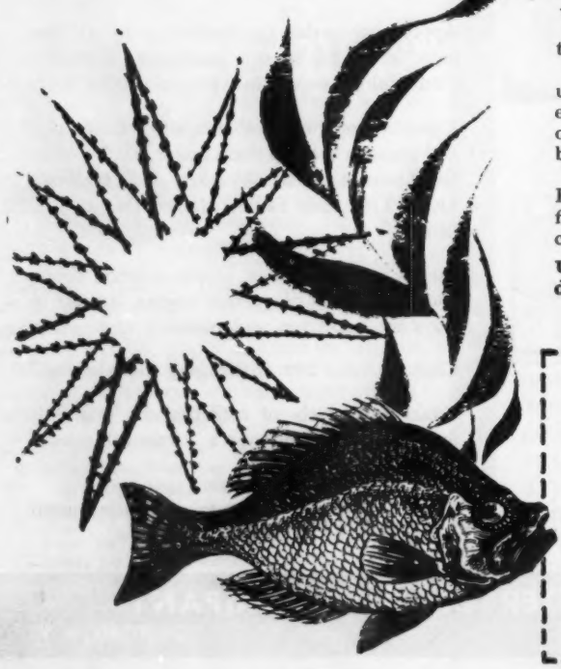

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The Size of the Universe. The Theory of Relativity. These two recordings by Dr. Edward Teller do a magnificent job of clarifying difficult subjects. In the *Size of the Universe,* he compares man's early legends about the earth with what is known today. He describes the solar system, the milky way galaxy, and the nature of outer space and the extra-galactic systems.

In the *Theory of Relativity,* Dr. Teller presents a difficult theory in an understandable manner. This record should be available in all high school science departments for general science, earth science, and physics students. 33⅓ rpm. $5.95. 1958. Spoken Arts Corporation, 95 Valley Rd., New Rochelle, N. Y.

Life Cycle of a Duck. Illustrates the life cycle of the Muscovy duck. Some simple principles of heredity in the Muscovy are illustrated through sketches and actual photographs of ducks with distinctive black and white color patterns. Hatching of duck eggs, care of the young, feeding habits, and adaptations are depicted. Excellent photographs of the movement of the nictitating membrane are shown. Recommended for junior high general science or biology. 11 min. Color $110, B&W $60. 1959. Bailey Films, Inc., 6509 De Longpre Ave., Hollywood 28, Calif.

Formulas in Mathematics. A pilot is shown using the formula, *D* equals *rt,* to find the distance he has traveled in a known direction and when he will arrive at his destination. This formula is represented graphically and pictorially. The understanding of the importance of mathematical units is stressed. Film may be useful to the junior high school science teacher in his presentation of simple machines and of interest to the senior high school physics teacher as a simple introduction to the study of motion. 10 min. Color $110. 1960. International Film Bureau, Inc., 57 East Jackson Blvd., Chicago 4, Ill.

Man and the Moon. Wernher Von Braun narrates an outstanding film featuring the development of an orbiting space satellite. A multi-stage rocket is used as a vehicle to send parts of the space island or platform to an orbit around the earth. Here the platform is assembled, the space island is manned, and preparations for the moon trip are made. The trip to the moon is then enacted. Moon's surface features are photographed. 20 min. Color $200. 1960. Walt Disney Productions, 2400 West Alameda Ave., Burbank, Calif.

Mars and Beyond. Presents the possibility of life on planets other than the earth. Temperature conditions and nature of gases for higher life are described. Explains man's

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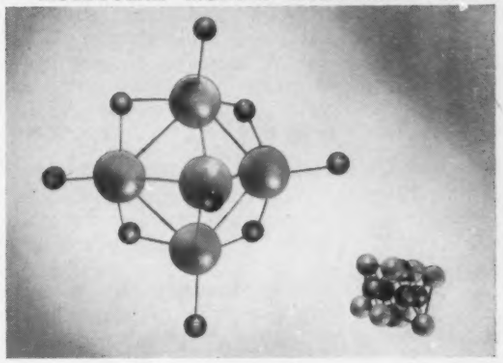

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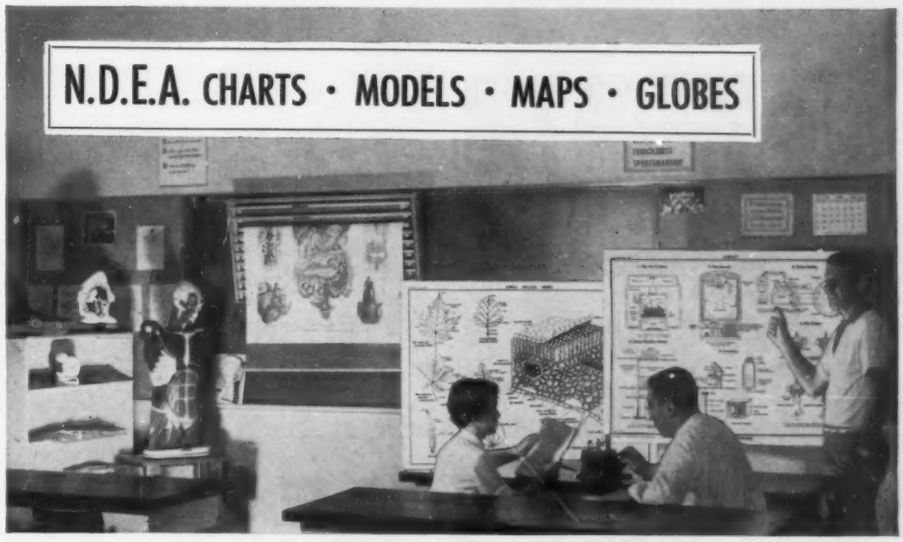

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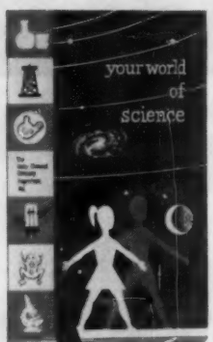

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Bausch & Lomb, Inc. 28
Bell Telephone Laboratories 48
Buck Engineering Company, Inc. 21
Cambosco Scientific Company 38
Can-Pro Corporation 59
Central Scientific Company 50
Clay-Adams, Inc. 52
Corning Glass Works 54
Coronet Films 78
Criterion Manufacturing Company .. 53, 76
Doerr Glass Company 44
Doubleday & Company, Inc. 24
Edmund Scientific Company 70
Educators Progress Service 53, 71
Field Enterprises Educational Corporation ..... Cover II
Ginn and Company 26
The Graf-Apsco Company 30
Harcourt, Brace and Company, Inc. ... 20
Harvard Apparatus Company, Inc. 71
D. C. Heath and Company 34
Laboratory Furniture Company, Inc. ... 75
Leslie Laboratories 74
Magnetic Devices, Inc. 73
McGraw-Hill Book Company, Inc. 47
Medical Plastics Laboratory 59
Morris and Lee 76
National Science Teachers Association .. 46
The New American Library 66
Northeast Enterprises, Inc. 79
A. J. Nystrom & Company 79
Ohaus Scale Corporation ..... Cover IV
Phipps & Bird, Inc. 57
Porter Chemical Company 80
Precision Apparatus Company, Inc. ... 43
Prentice-Hall, Inc. ..... Cover III, 62
Row, Peterson and Company 77
Science Materials Center 77
Science Publications 68
Scientific Demonstration Equipment Company 56
E. H. Sheldon Equipment Company .. 40-41
The Shell Companies Foundation, Inc. .. 1
John E. Sjostrom Company, Inc. 31
Swift Instruments, Inc. 74
Testa Manufacturing Company 64
Unitron Instrument Division, United Scientific Company 14-15, 66
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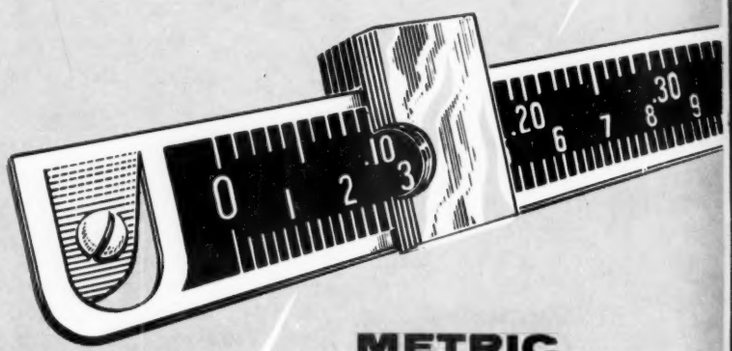

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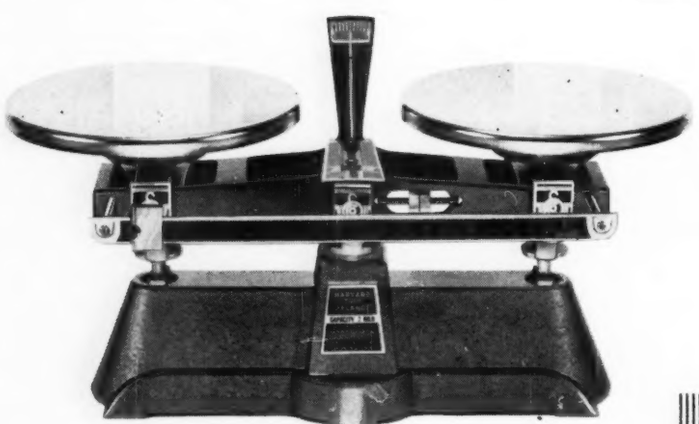

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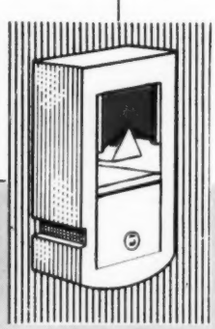

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